CMFRI

वार्षिक प्रतिवेदन
Annual Report
2010-11

Central Marine Fisheries Research Institute

(Indian Council of Agricultural Research)

Post Box No. 1603, Ernakulam North P. O., Cochin - 682 018, Kerala, India

भाकृअनुप
ICAR

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PREFACE

To remain focused is not to miss the rich picture. Our efforts to generate a dynamic knowledge base through interdisciplinary research for enabling a sustainability-oriented policy climate in the marine fisheries sector are being presented here in a new thematic format. This reflects more of a change in the way we approach our challenges than an editorial shift. In fact, this reiterates our commitment towards a broadened vision in collecting, analysing and disseminating basic knowledge which is essential for meeting the future needs of marine management and governance.

The marine production front with a total landing of 3.07 million tonnes is maintaining its economic vibrancy. But the declining trends in growth rate and disturbing manifestations of biological reference points do not augur well for complacency in ushering a scientifically informed management regime. Enhanced knowledge is the corner stone of science based ocean policies. It is heartening to see that the open access knowledge policy we have followed by way of launching e-prints@cmfri has been well received by our stakeholders nationally and globally. We have continued our pioneering attempts in taming our seas as an alternative food production system by way of the open sea cage farming technology we have developed. The technology is now ready for take off. What is required is a proactive policy and financial support that enables its wider diffusion among the coastal community.

The completion of the Marine Census 2010 once again proves our competence in undertaking such nationwide exercises. Our performance in generating cutting- edge, marketworthy technologies in the fields of mariculture and marine biotechnology has been more than gratifying. With the new statistical models we could develop, we have strengthened our resource assessment capabilities. The resource divisions have continued to generate vital information through focused research efforts. Fields like marine biodiversity and fisheries socio- economics have opened new vistas through innovative research methods bolstering deeper community partnerships. While presenting this report to our stakeholders, I have the privilege of acknowledging the unstinted support I have received from the Director General ICAR as well as the team of scientists and other members of the CMFRI fraternity.

30th June, 2011
Kochi

G. Syda Rao
Director

कार्यकारी सारांश

केंद्रीय समुद्री मात्स्यिकी अनुसंधान संस्थान ने वर्ष 2010-11 में प्राथमिकता के आधार पर अनुसंधान कार्यों का पुर्नविन्यास किया। चुने गए 19 मूल विषयों पर किए गए कार्य संस्थान की अनुसंधान परियोजनाओं के ज़रिए व्यक्त किए हैं। समुद्री मछली की पकड, पालन और अन्य वैज्ञानिक उद्यमों पर मिली उपलब्धियों का संक्षेप नीचे दिया जाता है।

वर्ष 2010 के दौरान विविध प्रकार के मत्स्यन संभारों से 3.07 मिलियन टन मछली पकडी गई। पिछले वर्ष 2009 की तुलना में यह करीबन 1.31 लाख टन कम है। कुल मछली अवतरण में 55% वेलापवर्ती पखमछली, 26% तलमज्जी, 14% क्रस्टेशियाई और 5% मोलस्काई मछलियाँ थीं। कुल मछली अवतरण के 73% यंत्रीकृत सेक्टर, 25% मोटोरीकृत सेक्टर और 2% कारीगरी सेक्टर का योगदान था। पश्चिम तट से 55% और पूर्व तट से 45% मछली पकड प्राप्त हुई। कुल मछली अवतरण में तारली *सारडिनेल्ला लोंगिसेप्सस* की पकड 4,03,932 टन के साथ 13.1% थी। इसके पीछे 2,43,154 टन के साथ बाँगडा *रास्ट्रलिगर कानागुर्ता* प्राप्त हुई जिसका प्रतिशत 7.9 था। अन्य प्रमुख पकड मछलियाँ पेनिआइड झींगा (2,17,858 टन, 7.5%), क्रोकर्स (1,66,967 टन, 5.4%), शीर्षपाद (1,66,776 टन, 5.4%) थीं।

केरल तट में वर्ष 2009 की तुलना में रिपोर्टाधीन वर्ष में 2.3% वृद्धि के साथ 5,30,078 टन मछली प्राप्त हुई। 57 वर्गों की मछलियों की पकड का मोनिटरन किया जिन में 19 वर्गों की पकड में वृद्धि देखने पर 38 वर्गों में कमी रेकोर्ड की। लक्षद्वीप की मुख्य पकड ट्यूना में पिछले वर्ष की अपेक्षा 4.6% घटती देखी गई; मिली पकड 7,883 टन ट्यूना थी। वर्ष 2010 में कर्नाटक की मछली पकड में सर्वकालीन वृद्धि हुई; मिली पकड 3,32,311 टन थी। पिछले वर्ष की तुलना में मोलस्क विशेषकर शीर्षपाद (118%) और वेलापवर्ती मछलियाँ जैसी फीतामीन (73.7%), करंगिड्स (51.1%) और बाँगडों (41.8%) की पकड में हुई वृद्धि इसका कारण है। गोवा की मछली पकड में 89,451 टन के साथ 25.3% वृद्धि हुई। महाराष्ट्र की मछली पकड में पिछले वर्ष की तुलना में 29% घटती हुई, मिली अनुमानित पकड 2.25 लाख ट. थी। गुजरात की पकड में भी 0.3% की उपांतिक घटती हुई; मिली पकड 5.06 लाख ट. थी। तमिलनाटु और पुदुच्चेरी से प्राप्त पकड यथाक्रम 5.55 लाख ट. और 14,525 ट. थी। आंध्राप्रदेश की समुद्री मछली पकड 2.53 लाख ट. थी जो कि पिछले वर्ष की तुलना में 0.5% कम है। उत्तर-पूर्व तट क्षेत्र में स्थित उड़ीसा और गुजरात से कुल मछली अवतरण का 18% प्राप्त हुआ।

भारत की मात्स्यिकी संपदा पर ऑपन बग्स सोफ्टवेयर के ज़रिए किए विश्लेषणात्मक अध्ययन से केरल, कर्नाटक, तमिलनाटु और पश्चिम बंगाल की मात्स्यिकी पकड की श्रम-काल डॉटा तैयार की गई। मान्नार की खाडी में इकोपाथ मोडल से तैयारित अध्ययनों से व्यक्त हुआ कि किए गये वर्धित पकड श्रम से पकड संचय में कमी हुई है और इसलिए इस क्षेत्र में पकड श्रम घटाना अनिवार्य है।

अधिकांश भारतीय तटों में उप पकड के रूप में फेंक देनेवाली कूडा-कचडा मछलियों पर किए अध्ययन ने व्यक्त किया कि करीबन 3.83 लाख ट. उप पकड मछली के रूप में नष्ट होता है जिसका मूल्य 192 करोड रु हो सकता है। कुल ट्राल पकड में इसका योगदान 27.8% है और पिछले वर्ष की तुलना में यह 24% बढ गई है।

अरब महासागर और पूर्व दिशा में 100 मी. से 4000 मी. (8^0 N से 17^0 N अक्षांश और 64^0E 76^0 E रेखांश) में एम वी टैटानिक (20 मी. LOA) नामक मत्स्यन ट्रालर द्वारा अन्वेषणात्मक सर्वेक्षण और जिग्गिंग पर्यटन चलाए गए। अरब महासागर में महासागरीय स्क्विड *स्टीनोट्यूथीस औलाएनसिस* का नया प्रजनन गेह ढूँढ निकाला गया।

गहरा सागर श्रिंप ट्रालरों द्वारा किए गए मत्स्यन में प्रति ट्रिप में 840 से 1680 कि. ग्राम कवच मात्स्यिकी प्राप्त हुई। भारत के दक्षिण भाग और भारतीय महासागर में श्रीलंका के सन्निकट समुद्रों में FORV सागर संपदा के ज़रिए समुद्री स्तनियों की विविधता व वितरण आंकने का अध्ययन चलाया गया।

खाद्यशुक्ति *पिंक्टाडा फ्यूकाटा* को प्रभावित करनेवाले आंटिऑक्सिडन्ट एनज़ाइम, स्ट्रेस सबंधी प्रोटीन और प्रतिरोध संबंधी पेप्टाइड के तीन वर्गों का प्रकार्यात्मक जीन का पहचान और वर्णन किया गया। *पिंक्टाडा फ्यूकाटा* में मोती रूपायन करनेवाले जीन के सान्निध्य का भी अध्ययन किया गया। आर्टीमिया के संदर्भ में *आर्टीमिया फ्रांसिस्काना* के संकर प्रजनन में होनेवाली कार्यक्षमता का अध्ययन किया गया।

मंडपम में पिंजरा पालन किए कोबिया अंडजनक में पुनरुत्पादकीय इतिवृत्त समझने को PIT टैगन किया गया। संस्थान के अनुसंधान केन्द्रों में कोबिया, पोंपानो, ग्रीसी ग्रूपर और मलबार रेड स्नाप्पर मछलियों के अंडशावक विकास किया गया। चेन्नई के कोवलम में महाचिंगट संततियों व डिम्भकों के पालन करने की विधा विकसित की।

चेन्नई व कारवार में सीबास और कन्याकुमारी में महाचिंगट के पिंजरा पालन से मिली बंपर पकड ने पिंजरा पालन पद्धति की सफलता की ओर प्रकाश डाला। मंडपम में पिंजरा पालन पद्धति से मिली कोबिया संततियों का भार 8 महीने में 2.5 से 3.5 कि. ग्रा. हो जाना इस पद्धति के ज़रिए पालन केलिए अनुयोज्य जाति साबित किया। कोचीन के खारापानी में पेर्ल स्पॉट (करिमीन) और ग्रे मुल्लट पर किए पालन पद्धति ने इन्हें पिंजरा पालन केलिए अनुयोज्य जाति साबित किया।

विषिंजम, तंकश्शेरी क्षेत्र में किए गए जैवविविधता सर्वेक्षणों ने *पोसिल्लोपोरा डार्मिकार्निस*, *पी. वेरिकोसा* आदि प्रवालों के वितरण की सूचना दी। *एल. पासिफ्लोरम* नीचे धरातल में पालन के बीस दिवस के बाद उगते हुए देखा। पाक की खाडी में बोट्टम सेट गिलनेट और मिनिट्रालरों के द्वारा जैवसंपदा पर होने वाला नाश व्यक्त था। विश्युअल सेनसस मेथेड से प्रवाल झाडियों में मछलियों और स्पंजों का सहवास समझ गया। भारत की मान्नार खाडी में पहली बार *रीनोपियास एसकमेरी (Rhinopias eschmeyeri)* और *अब्लाबिस बैनोटाटस (Ablabys binotatus)* के संबंध में रिपोर्ट की गई।

केरल के मूत्तकुन्नम में सामुदायिक सहयोग से आयोजित समुद्री पारिस्थितिक तंत्र के पुर्ननवीकरण कार्यक्रम में *ब्रूगीरा गिम्नोरिज़ा* और *बी. सिलिंट्रिका* नामक कच्छ वनस्पतियों का विकास किया। दक्षिण कन्नड के कुडुरोली में *रैज़ोपोरा म्यूक्रोनेटा* की एक नर्सरी भी विकसित की। कोची के आसपास अरब खाडी की 30 मी. गहराई के तटीय पारिस्थितिक तंत्र के अवसाद की गुणता व जलराशिकीय बदलावों पर संग्रहित डाटा का अंकन किया गया। पानी की पौष्टिकता में उतार-चढाव से होनेवाला प्रफुल्लन का दशकीय मूल्यांकन किया गया। महाराष्ट्र और केरल की तटीय जिलाओं में जलवायु परिवर्तन से होनेवाली स्थिति-गतियों का अध्ययन किया गया। फरवरी 2011 में समुद्री मात्स्यिकी पर जलवायु परिवर्तन से होनेवाला लाभ उठाने के विषय पर नैशनल इनीश्येटिव ऑन क्लैमट रेसिलियंट अग्रिकलचर- मरैन फिशरीस परियोजना (NICRA) की शुरूआत की।

रिपोर्टाधीन अवधि में समुद्री मात्स्यिकी की समाजार्थिक परिवेश में प्रकटात्मक बदलाव हुआ। मछली का पकड मूल्य 19,753 करोड रुपये आकलित करने पर बिक्री मूल्य 28,511 करोड रु आकलित किया याने कि 14.35% वर्द्धन है। निजी क्षेत्र से मात्स्यिकी में 15,496 करोड रुपयों का निवेश हुआ जिन में 87% यंत्रीकृत यानों केलिए 8.5% मोटोरीकृत यानों केलिए व 4.5% अयंत्रीकृत यानों केलिए है।

सी एम एफ आर आइ के प्रकाशन ऑपन अक्सेस इंस्टिट्यूशनल रिपोसिटरी, ई प्रिंटस @ सी एम एफ आर आइ के ज़रिए पढने और प्रिंट आऊट लेने की विधा स्थापित की गई। वर्ष 2010 -11 के दौरान संस्थान ने 71 राष्ट्रीय और अंतर्राष्ट्रीय पत्रिकाएं खरीदीं। संस्थान ने वर्ष 2009 में उत्तम राजभाषा निष्पादन का भा कृ अनु प द्वारा स्थापित राजर्षि टंडन अवार्ड जीत लिया।

कृषि विज्ञान केंद्र द्वारा तेवरा में स्थापित परीक्षणात्मक खेत में मक्का की सफल खेती की गई। केरल में यह पहला परीक्षण है।

समुद्री मात्स्यिकी जनगणना - 2010 के ज़रिए तटीय मछुआ ग्रामों व परिवारों की विशद डाटा संकलित किया। संस्थान ने पिंजरा पालन, अलंकारी मछली पालन और शंबु पालन विषयों पर विंटर स्कूल और एन एफ डी बी प्रशिक्षण कार्यक्रम आयोजित किया। वैज्ञानिकों ने राष्ट्रीय और अन्तर्राष्ट्रीय प्रशिक्षण कार्यक्रमों और सागरीय पर्यटनों में भाग लिया ।

वर्ष के दैरान संस्थान ने 33 गृहांदर, 32 प्रायोजित और 15 परामर्श परियोजनाएं कार्यान्वित कीं। संस्थान ने प्रमुख पत्रिकाओं में 68 अनुसंधान लेख प्रकाशित किया। समुद्री मात्स्यिकी पर 30 तकनीकी लेख व 23 लोकप्रिय लेख प्रकाशित किए। किताब, किताब खंड और प्रक्रिया साहित्य को जोडके 30 प्रकाशन निकाले गए।

Executive Summary

CMFRI has reoriented marine fisheries research and prioritized 'focus areas' during the year 2010-11. The progress achieved based on the selected 19 themes of 'topical value' is reflected in the research projects of the Institute. The salient findings in capture, culture and other related scientific endeavours are summarized as follows:

The multi-gear capture fisheries of India estimated provisionally at 3.07 million during the year 2010 showed a decrease of about 1.31 lakh tonnes compared to 2009. The pelagic finfishes constituted 55%, demersal 26%, crustaceans 14% and molluscs 5% of the total landings. The mechanized sector contributed 73%, motorized 25% and artisanal 2% of the catch. The west coast accounted for 55% and east coast 45% of the total landings. The oil sardine *Sardinella longiceps* contributed to the maximum (13.1%) with an estimated landing of 4,03,932 t against 4,14,767 t in 2009 followed by Indian mackerel *Rastrelliger kanagurta* (2,43,154 t; 7.9%). The other important resources were penaeid prawns (2,17,858 t; 7.1%), croakers (1,66,967 t; 5.4%), cephalopods (1,66,886 t; 5.4%) *etc*.

The marine fish landings along the Kerala coast were 5,30,078 t during 2010 which was 2.39 % more than 2009. Among 57 important groups of fishes monitored, 38 showed a decline while 19 projected an increase in yield. Tunas formed 81.3 % (7,883 t) of the total catch in Lakshadweep though declined by 4.6% in 2009. Karnataka recorded an all time high of 3,32,311 t marine fish landing during 2010. Increase in the landings of molluscs especially cephalopods (118%) and pelagics (ribbonfish (73.7%), carangids (51.1%) and mackerel (41.8%)) as compared to the previous year led to this overall increase. The marine fish production in Goa showed 25.3% increase (89,451 t) during 2010. The marine fish landings in Maharashtra during 2010 was estimated provisionally at 2.25 lakh t, with a decline of 29% over the previous year and that in Gujarat at 5.06 lakh t with a marginal reduction of 0.3%.

In Tamil Nadu the catch was 5.55 lakhs t and Puducherry 14,525 t. The total marine fish production of Andhra Pradesh for 2010 was 2.53 lakh t with a slight reduction of only 0.5% from that in 2009. West Bengal and Orissa contributed 18% to the total production of the north east region.

The landing of low value bycatch and discards from trawl fisheries was monitored at Veraval, Mumbai, Karwar, Mangalore, Calicut, Cochin, Tuticorin, Mandapam, Chennai and Visakhapatnam. An estimated 3.83 lakh t of bycatch valued at Rs.192 crores was landed which formed 27.8 % of the total trawl catch, an increase of 24% over the previous year.

Fifteen exploratory surveys and jigging cruises were undertaken in a fishing trawler MV *Titanic* (20 m LOA) from 100 m to 4,000 m (8°N to 17°N lat. and 64°E to 76°E long.) along the Eastern and Central Arabian Sea. New spawning grounds of oceanic squid *Sthenoteuthis oualaniensis* were located in the Arabian Sea.

Myctophid fishery by deep sea shrimp trawlers constituted 840 to 1,680 kg/trip. Two opportunistic visual surveys were carried out onboard FORV *Sagar Sampada* to assess marine mammal diversity and their distribution in oceanic waters of western and eastern parts of the Indian seas and southern part of Sri Lankan waters of Indian Ocean.

Identification and characterization of the functional genes belonging to three categories *viz*. anitoxidant enzymes, stress related proteins and defense related peptidases in edible oyster

Crassostrea madrasensis, and the genes involved in pearl formation in *Pinctada fucata* were carried out. Functional feeds were developed and nutritional trials were made for open sea cage farming, ornamental fishes and lobsters. Oysters were screened for the presence of *Perkinsus olseni* and anti-inflamatory properties of green mussels were studied.

PIT tagging has been introduced in obtaining the reproductive history of the cage reared cobia brooder at Mandapam. Broodstock development for cobia, pompano, greasy grouper and Malabar red snapper is in progress at different centres. A recirculatory system for lobster broodstock and larval rearing has been introduced at Kovalam, Chennai. Good harvests obtained in cages for seabass at Chennai and Karwar and for lobster at Kanyakumari have boosted the prospects of cage farming. Cobia seeds produced by CMFRI in cages at Mandapam and the record growth obtained (2.5 to 3.5 kg in 8 months) show the excellent prospects of the species in cage farming. Growth of grey mullet and pearl spot (*Karimeen*) in captivity in brackishwater environment off Cochin has opened up yet another avenue for selecting candidate species for cage culture.

Biodiversity surveys at Vizhinjam-Thankassery areas revealed the presence of patchy coral reefs dominated by *Pocillopora damicornis* and *P. verrucosa. Cladiella australis* (soft coral), is a new distributional record for the Palk Bay reef ecosystem. *L. pauciflorum* explants were found to attach firmly to the substratum after 20 days of culture and growth of new lobes and polyps were visible by 25th day. The bottom set gill nets and mini-trawls were found to cause destruction to the sponges in the Palk Bay. Fish assemblages and sponges associated with coral reefs were studied using visual census method. *Rhinopias eschmeyeri* and *Ablabys binotatus,* both new to Indian waters were reported from the Gulf of Mannar.

The OpenBugs software, a Markov Chain Monte Carlo (MCMC) based Bayesian analysis tool, was used to study the state-space models on various fisheries in India. OpenBugs codes for non-linear Schaefer model were developed for 15 year catch and effort time series data sets of Kerala, Karnataka, Tamil Nadu and West Bengal. Using the constructed ECOPATH model of the Gulf of Mannar, it was observed that effort increase resulted in drastic reduction in the cumulative catch and therefore effort control is very much necessary in the GOM ecosystem.

Nursery of mangrove plants was developed at Moothakunnam, Ernakulam and Kuduroli in Dakhshina Kannada through participatory community based Marine Ecosystem Restoration Programme. Data on hydrographic variations and sediment quality of the coastal ecosystem (upto 30 m depth, off Kochi) collected since 1995 to 2010 was digitized. A decadal change in the nutrient level indicative of eutrophication was also evaluated. Vulnerability assessment of coastal villages in the districts of Maharashtra and Kerala to climate change was studied. A promising project on National Initiative on Climate Resilient Agriculture – Marine Fisheries (NICRA) was launched in February 2011 with the theme "Harnessing the beneficial effects on climate change on marine organisms".

The socio-economic scenario of the marine fisheries showed discernible changes during the period. The gross revenue from the catches at the point of first sales (landing centre) was estimated at Rs.19,753 crores, and at the point of last sales (retail market) it was estimated at Rs.28,511 crores resulting in an enhancement of 14.35%. The estimated gross private investment on fishing equipment was at Rs.15,496 crores**,** out of which the investment on mechanised crafts worked out 87%, motorized crafts, 8.5% and the non-mechanized crafts, 4.5%.

Open Access Institutional Repository, e-prints@CMFRI has been established for the research publications. During 2010-11, the Institute subscribed 71 national and international journals including online versions. CMFRI won the Rajarshi Tandon Award (second position) of ICAR for the excellent implementation of Official Language activities for the year 2009.

Maize crop was successfully cultivated through 'On Farm Testing' by the KVK at the KVK demonstration farm in Thevara for the first time in Kerala.

Marine Fisheries Census - 2010 was successfully completed generating detailed information on the coastal villages and fisherfolk. The Institute had conducted ICAR Winter School and NFDB national training programmes in different areas like cage culture, ornamental fish culture and mussel farming, followed by several workshops. Scientists have participated in national and International trainings and in cruises upto the Southern Ocean.

The Institute has implemented 33 in-house, 32 sponsored and 15 consultancy projects. We have published 68 research papers in peer reviewed journals, 30 technical articles, 23 popular articles and 6 books in different areas of marine fisheries research.

INTRODUCTION

The Central Marine Fisheries Research Institute plays a pivotal role in the field of fisheries research in India with its 63 years of splendid and dedicated service, focusing on various aspects of marine fisheries, which target sustainable fish production and well-being of fishermen communities. Ever since its establishment in 1947, the Institute grew significantly in developing a creditable research infrastructure and scientific expertise, enabling a multidisciplinary approach in marine capture as well as culture fisheries. The marine fisheries sector of India, which contributes about 45% of the total fish production of the country, plays a noteworthy role in supplying protein rich food to the growing population and attracts rewarding foreign exchange earnings through seafood export. The vast expanse of the coastline of the country offers ideal sites for mariculture through which, the Institute is aiming at enhancing the production of food fishes along with developing appropriate strategies for sustainable management and conservation of biodiversity of the EEZ. In accordance with the global trends in marine fisheries management, the fishing industry in India should also attempt to meet the challenges of formulating a successful management system that addresses sustainability issues. In this context, the initiatives taken up by CMFRI in research on ecosystem-based fisheries and participatory approach in fisheries management stand relevant.

The marine fish landings of India, estimated during 2010 was 3.07 million tonnes which recorded a decline of about 1.31 lakh tonnes when compared to the estimate for 2009. The pelagic finfishes constituted bulk of the landings with a share of about 55%. The west coast continued to be the major contributor. The recent fishery statistics of the country shows that the present fishing effort has been substantially extended to deeper waters with the induction of more multiday vessels. However, there is ample scope for further expansion to oceanic waters to exploit the non-conventional resources as well as oceanic tunas. Aiming at this objective, steps to utilise the oceanic tuna of the Lakshadweep Sea as well as oceanic squids and myctophid resources have been envisaged through NAIP schemes.

The national marine fish landing estimates by the Institute using comprehensive centralised sample survey programme is well accepted and utilised by the researchers and institutions globally. The statistical methodology adopted for estimation, covering 1,332 landing centres in nine maritime states of India was recognised by FAO and was officially reported to FAO upto 1970 as official statistics. The database pertaining to the fishery and biology of commercially exploited marine finfishes as well as shellfishes offer immense scope for their collation and dissemination, which in turn, may help in formulating the best management practices for fishery regulations and stock enhancement. In the recent past, the Institute was assigned with the tasks of revalidation of potential yield of the Indian EEZ, optimisation of fleet size for different maritime sates of India and a study on the impact of the seasonal fishing ban based on analysis of the time series data deposited at the National Marine Living Resources Data Centre of CMFRI. The Institute has also proclaimed its prime role in fishery sector by successfully accomplishing the gigantic task of conducting the Marine Fisheries Census - 2010, to generate reliable and latest data on fishermen population, craft and gear and infrastructure facilities of fishing villages, covering about 11 lakh marine fishermen households distributed across 4,044 fishing villages in the country.

The success in open sea cage farming of Asian seabass *Lates calcarifer* in the coastal waters has opened up new avenues in formulating policies for the commercialisation of cage culture with location specific environmental impact assessment studies. The institute has pioneered in identifying resources necessary for sea cage farming and has taken the front stage in this direction. While the efforts continue for the commercialisation of the holistic health solutions from the green mussel, 'GMe' and the ornamental fish feed 'Varna', subsequent success in this

The Mandate

- *To monitor the exploited and assess the under-exploited of the marine fisheries resources of the Exclusive Economic Zone (EEZ).*
- *To understand the fluctuations in abundance of marine fisheries resources in relation to change in the environment.*
- *To develop suitable mariculture technologies for finfish, shellfish and other culturable organisms in open seas to supplement capture fishery production.*
- *To act as a repository of information on marine fishery resources with a systematic database.*
- *To conduct transfer of technology, post-graduate and specialised training, education and extension-education programmes.*
- *To provide consultancy services.*

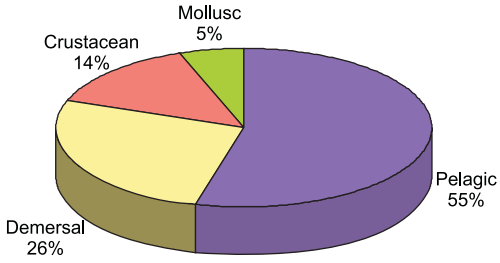
line has been achieved with the development of functional feeds for aquariculture and slow sinking nursery feeds.

In order to imbibe the mandatory principles of CMFRI, the Institute performs regular investigations on the impacts of fishing and other human interventions on the natural stocks and marine ecosystems, develops hatchery production systems and sea farming techniques of finfishes as well as shellfishes to augment production, undertakes research on the ocean environment dynamics and climate change impacts, trends and traits of vulnerable biota and habitats coupled with marine biodiversity to conserve the resources and build up a reliable database. Data archaeology, socio-economic evaluation, technology transfer and participatory approach in co-management of the resources for responsible harvesting practices are also appraised and incorporated.

The Institute has three Regional Centres; at Mandapam Camp, Visakhapatnam and Veraval; seven Research Centres; at Mumbai, Karwar, Mangalore, Kozhikode, Vizhinjam, Tuticorin and Chennai and fifteen Field Centres along both the west and east coasts to investigate and accomplish the tasks envisaged. The entire activity is co-ordinated by the Headquarters at Cochin, with its ten Research Divisions namely, Fisheries Resources Assessment, Pelagic Fisheries, Demersal Fisheries, Crustacean Fisheries, Molluscan Fisheries, Fishery Environment Management, Marine Biotechnology, Mariculture, Marine Biodiversity and Socio-Economic Evaluation and Technology Transfer. The Institute has built up laboratories, hatcheries and farming facilities for carrying out research programmes over the years and is in the process of upgrading the same to meet the additional requirements and challenging needs. CMFRI provides facilities for Ph. D. programmes of several Universities in the country with the involvement of externally funded research schemes. The Library and Documentation Section of the institute provides online documentary service from time to time inclusive of e-prints to research staff and students of CMFRI, besides extending reference facilities to visitors. The Institute brings out *Bulletins*, *Special Publications*, Quarterly Newsletter and the *Marine Fisheries Information Service* and also publishes the *Indian Journal of Fisheries* to aid successful dissemination of the results of scientific research.

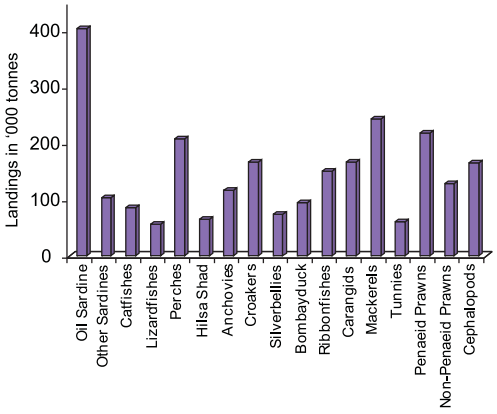
FISH HARVESTS

Marine fish landings and fishing effort for different regions of the country with individual species and gear-wise break up were estimated and a full fledged information retrieval system pertaining to marine fisheries was developed. For collection and estimation of marine fish landings of the exploited marine fishery resources, the time-tested stratified multistage random sampling design developed by the Institute was adopted which involved planning and execution of the sample survey, co-ordination of field work, processing of data, development of necessary computer software, creation and updating of database, development of formats for data storage and retrieval and development of database queries.



Components of marine fish landings in India during 2010

- *The marine fish landings of India during the year 2010 has, provisionally, been estimated as 3.07 million tonnes with a decrease of about 1.31 lakh tonnes compared to the estimate for 2009.*
- *The pelagic finfishes constituted 55%, demersal fishes 26%, crustaceans 14% and molluscs 5% of the total landings.*
- *The sector-wise contributions during the year 2010 were mechanized 73%, motorized 25% and artisanal 2%.*
- *The west coast accounted for 55% of the total landings and east coast 45%.*

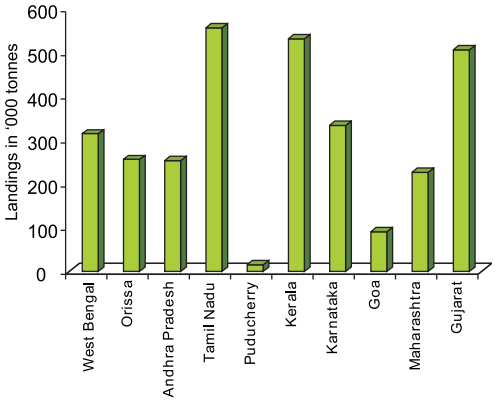


Landings of major fishery resources during 2010

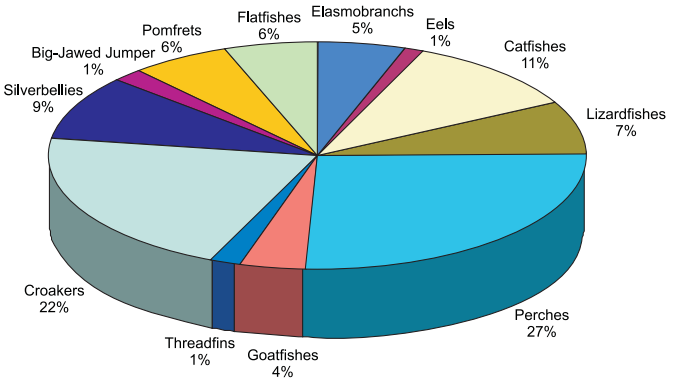
Region-wise and resource-wise estimates of marine fish production were made along with the effort expended by different types of gears. The estimate of region-wise production showed that the north-east region, comprising West Bengal and Orissa contributed 18% to the total production and the south-east region consisting of Andhra Pradesh, Tamil Nadu and Puducherry contributed 27%. On the west coast, the north-west region comprising Maharashtra and Gujarat recorded 24% of the total landings, and the south-west region comprising Kerala, Karnataka and Goa contributed 31%.

Contribution of major species/groups

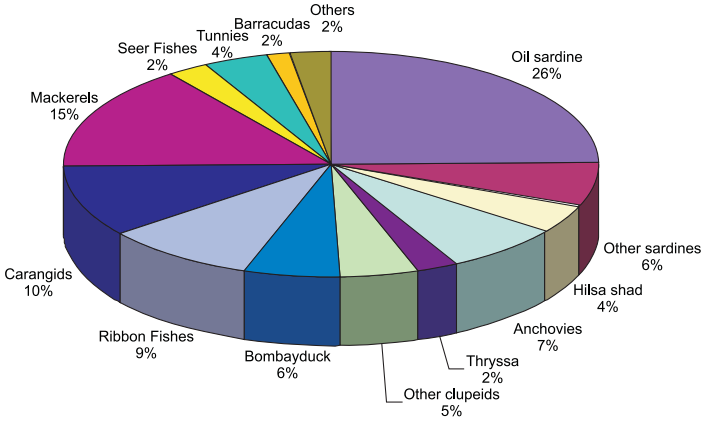
Oil sardine (*Sardinella longiceps*) remained as the most important single species contributing 13.1% to the total marine fish landings in the country. The estimated landings of oil sardine for 2010 is 4,03,932 tonnes against 4,14,767 tonnes in 2009. The second important resource in terms of contribution towards total landings is Indian mackerel (*Rastrelliger kanagurta*) accounting for 7.9% of total landings, the estimate for 2010 being 2,43,154 tonnes compared to 1,85,932 tonnes in 2009. The estimated landings of other important resources are penaeid prawns 2,17,858 tonnes (7.1%), croakers 1,66,967 tonnes (5.4%), cephalopods 1,66,886 tonnes (5.4%), ribbonfishes 1,50,166 tonnes



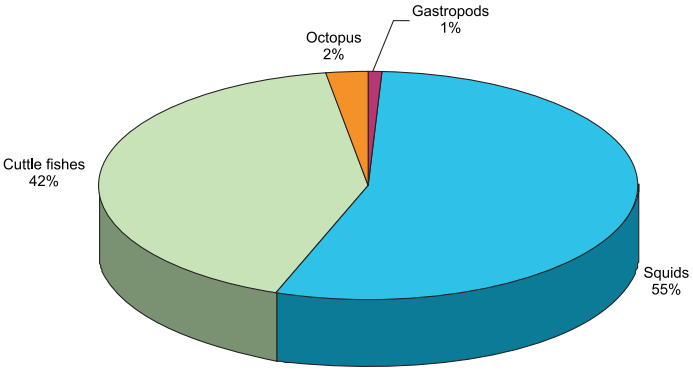
State-wise landings in India during 2010



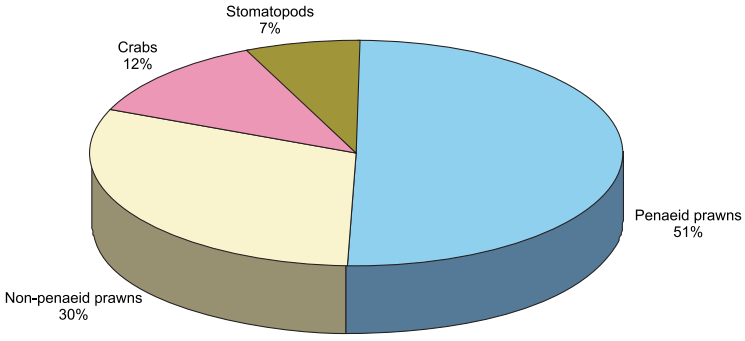
Demersal finfishes



Pelagic finfishes



Molluscs



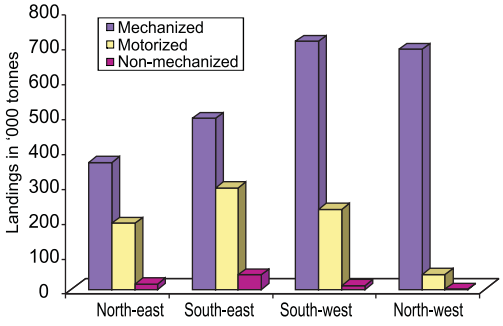
Crustaceans

Components of various groups in the marine fish landings of India during 2010

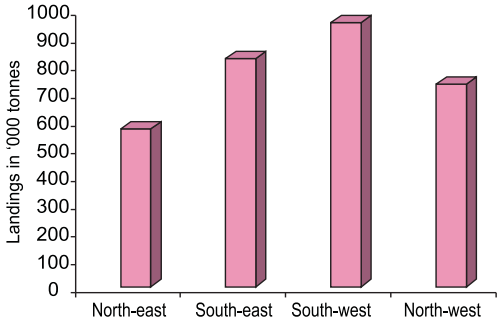
Estimated marine fish landings (t) during 2009 and 2010*

Pelagic finfishes			Demersal finfishes		
Name of fish	**2009**	**2010**	**Name of fish**	**2009**	**2010**
Clupeoids			Elasmobranchs		
Wolf herring	22137	17597	Sharks	29129	20245
Oil sardine	414767	403932	Skates	3742	2326
Other sardines	101054	103059	Rays	19906	18095
Hilsa shad	52051	65196	Eels	12408	9177
Other shads	6103	4233	Catfishes	107573	85699
Coilia	30518	26156	Lizard Fishes	59497	56480
Setipinna	13036	11339	Perches		
Stolephorus	56824	79127	Rock cods	17586	21812
Thryssa	38204	37775	Snappers	7676	8101
Other clupeids	83024	78618	Pigface breams	17004	8856
Bombayduck	112279	94942	Threadfin breams	130728	124248
Half Beaks & Full Beaks	6308	4692	Other perches	50819	45500
Flying Fishes	1458	786	Goatfishes	30031	34575
Ribbon Fishes	138592	150166	Threadfins	11767	9193
Carangids			Croakers	195934	166967
Horse Mackerel	34042	29647	Silverbellies	68480	73817
Scads	54018	48891	Whitefish	13626	11333
Leather-jackets	12591	12275	Pomfrets		
Other carangids	75000	75880	Black pomfret	17959	21647
Mackerels			Silver pomfret	31733	24397
Indian mackerel	185932	243154	Chinese pomfret	3478	3634
Other mackerels	196	199	Flat Fishes		
Seer Fishes			Halibut	938	1080
S. commerson	30384	26561	Flounders	134	162
S. guttatus	21655	13904	Soles	44572	42440
S. lineolatus	16	16	Miscellaneous	42988	19996
Acanthocybium spp.	227	177	**Total**	**917708**	**809780**
Tunnies			**Shellfish**		
E. affinis	25590	22101	Crustaceans		
Auxis spp.	8062	17914	Penaeid prawns	245159	217858
K. pelamis	7604	5767	Non-penaeid prawns	168415	128876
T. tonggol	3331	4451	Lobsters	1872	1683
Other tunnies	16131	10283	Crabs	47897	52149
Bill Fishes	9073	8303	Stomatopods	27379	29504
Barracudas	23052	25737	Molluscs		
Mullets	6824	3338	Cephalopods		
Unicorn Cod	724	152	Squids	54262	91438
Miscellaneous	78180	41178	Cuttle fishes	63718	69940
Total	**1668987**	**1667546**	Octopus	5659	4016
			Miscellaneous	4397	1492
			Total	**618758**	**596956**
			Grand total	**3205453**	**3074282**

* Provisional estimate



Sector-wise landings in different regions during 2010



Region-wise landings in India during 2010

(4.9%), non-penaeid prawns 1,28,876 tonnes (4.2%), threadfin breams 1,24,248 tonnes (4.0%), lesser sardines 1,03,059 tonnes (3.4%) and Bombayduck 94,942 tonnes (3.1%).

Revalidation of potential yield

The potential yield and optimum fleet size for the maritime states West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Puducherry, Kerala, Karnataka, Goa, Maharashtra and Gujarat, were estimated based on Schaefer's linear and non-linear surplus production models and using catch and effort time series data of each maritime state, for the committee constituted by the Ministry of Agriculture for revalidation of potential yield of the Indian EEZ.

Impact of fishery regulations

Based on 20 years catch and effort time series of four categories of marine fishery resources, possible influence of fishery regulation like trawl ban was studied for all the maritime states of the country for the committee constituted by the Ministry of Agriculture to review the centrally implemented fishing regulations along east and west coast of the country.

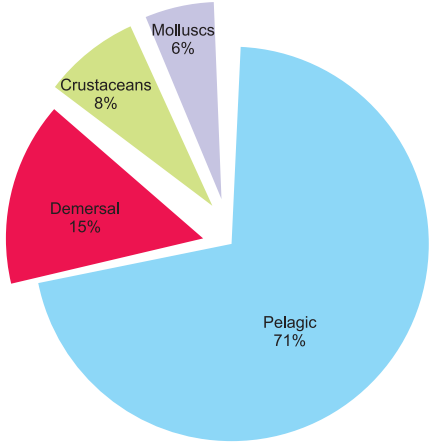
Sustainable Management of Fishery Resources

Kerala and Lakshadweep

Kerala

The total marine fish landings along the Kerala coast was 5.3 lakh t during 2010, which was 2.39% more than that of 2009 (5.18 lakh t). The overall increase recorded was due to the increased landing of small pelagics. Pelagic finfishes contributed 71%, demersal 15%, crustaceans 8% and molluscs 6% of the total landings. The contribution by mechanised, motorised and artisanal sectors were 62%, 37% and 1%, respectively. Of the 57 important groups of fishes monitored, 38 groups showed decline and 19 showed increase in yield during 2010. The estimate of district-wise fish production showed that Calicut ranked first with 21.4% followed by Ernakulam (19.8%), Alleppey (14.4%), Trichur (11.0%), Malappuram (9.0%), Kollam (8.6%), Kannur (8.1%), Thiruvananthapuram (5.9%) and Kasaragod (1.9%).

The major groups which contributed to the fishery of Kerala were oil sardine (35.5%), Indian mackerel (12.0%), anchovies (7.8%), penaeid prawns (6.5%), threadfin breams (6.4%), carangids (6.2%), cephalopods (6.1 %), flatfishes (2.6%), tunas (2.6%) and ribbonfishes (1.6%). Major gears that supported the fishery were ring seines (51.6%), multi-day trawlers (25.0%) out board motor gillnets (7.5%) and mechanized single day trawlers (5.0%). The most efficient gears were mechanized ring seine that yielded 1207.4 kg/hr followed by mechanized purse seine (979.2 kg/hr) and out board motor ring seine (713.4kg/hr). Highest landings were during October (69,564 t; 13.1%) while the lowest were in April (16,540 t; 3.1%).



Percentage contribution of various resources to the fisheries of Kerala

Pelagic resources

The pelagic resources constituted 71% (3,76 lakh t) of the total landings of Kerala. The major resources exploited were oil sardine (50%), Indian mackerel (17%), whitebaits (10.9%), carangids (8.7%), tunas (3.6%), ribbonfishes (2.2%), lesser sardines (1.9%) and seerfishes (0.8%).

Oil sardine: *Sardinella longiceps* contributed 35.5% (1,88,047 t) of the overall fish production in Kerala. Ring seine with a production rate of 824 kg/hr was the most efficient gear that contributed 98.8% of the sardine landings. Trawlers and gillnets contributed 0.9% (0.5 kg/hr) and 0.3% (1.1 kg/hr).

Indian mackerel: *Rastrelliger kanagurta* with 12.0% contribution (63,822 t) formed the second largest resource in the landings of Kerala. Ring seine with a production rate of 102.5 kg/hr contributed 56% and trawls 32.5 % (at 4.0 kg/hr) to the mackerel landings.

Whitebait (*Stolephorus* spp.) landings at Calicut

Whitebaits: *Stolephorus* spp. with 7.8% (41,192 t) contribution was the third most important resource. Most productive month was November. Trawlers contributed 55.5% with a catch rate of 1.25 kg/hr, ring seines 42.6% (at 13.4 kg/hr) and gillnets 2.0% (at 0.3 kg/hr). Four species were observed with the dominance of *S. devisi* 28.3 % (size range 70-95 mm) followed by *S. commersoni* 27.0 % (size range 75-155 mm), *S. waitei* 25.3 % (size range 70-100 mm) and *S. insularis* 12.3% (size range 64-85 mm). Entire catch was constituted by mature fishes.

Carangids: Formed nearly 6.5% of the total fish catch of the state (32,583 t). Fishery was supported by 35 species, with 9 at commercial level. *Decapterus* spp. formed nearly 55.3 % of the total carangid catch. Large carangids were exploited mainly by hooks and line (72.4%) and drift gillnets (25.4%) while small carangids by trawls (82.7 %) and ring-seines (17.3%). Young ones of scads were encountered in the catch round the year, with peak during south-west monsoon, accounting 22.4% of their annual catch.

Ribbonfish: Production improved over the previous year by 40% to 8,445 t. Fishery was intermittent along the coast with peak during October and supported exclusively by *T. lepturus*. Trawlers with 72.8% contributed the bulk of the catch followed by out board gillnets (23.7%) and out board hooks and lines (3.0%). Targeted fishery for juveniles was observed at Kollam region, especially for bait purpose for tuna longliners and handliners.

Ribbonfish (*Trichiurus lepturus*) landing by trawls at Calicut

Seerfishes: Major share (85.5%) of the production was by hooks and line, rest by gillnets (10.5%) ring seine and trawls. Fishery was supported by three species *Scomberomorus commerson* (93.0%), *S. guttatus* (4.0%) and *Acanthocybium solandri* (3.0%). Young fishes of 17-30 cm size (FL) were landed by trawls and ring seines almost round the year, with peak during June to September.

Billfishes: Exploited mainly by hooks and line (69.4%) and gillnets (30.6). Fishery was supported by *Istiophorus platypterus* (90.5%), *Makaira* spp. (8.9%) and *Xiphias* spp. (0.8%).

Cobia: An estimated 436 t of cobia (*Rachycentron canadum*) was landed by hooks and line, gillnets and trawls.

Estimates of exploitation and mortality rates of important pelagic sources

Species	E	F	Z	M	Remarks
Selar crumenophthalmus	0.51	1.75	3.42	1.67	Under-exploited
Decapterus russelli	0.48	1.52	3.13	1.61	Under-exploited
Megalaspis cordyla	0.68	2.84	4.20	1.36	Optimally exploited
Trichiurus lepturus	0.48	0.92	1.9	0.98	Under-exploited
Euthynnus affinis	0.76	4.01	5.30	1.29	Over-exploited
Auxis thazard	0.59	2.32	3.96	1.64	Under-exploited
Auxis rochei	0.35	0.66	1.87	1.21	Under-exploited
Scomberomorus commerson	0.76	7.33	9.64	2.31	Over-exploited
Rachycentron canadum	0.61	3.17	5.18	2.01	Over-exploited

Fishery parameters of important pelagic resources in Kerala

Resource	Size range	Dominant size group	Peak landing
Oil sardine	55 to 210 mm TL	120-190 mm	January and October
Indian mackerel	80-290 mm in TL	120-295 mm	October
Ribbonfishes	20-91 cm (Malabar)	62 to 80 cm	October
Ribbonfishes	63-112 cm (central Kerala)	72-87 cm	
Scomberomorus commerson	12-144 cm FL	45-104 cm	June to September
Cobia	24 -126 cm FL	56 – 58 cm and 88 – 96 cm	May and September
Carcharhinus limbatus	52.4-232.4 cm	120-180 cm	
Priacanthus hamrur	10.1- 41.0 cm	28.0 cm	

Management measures

The mean size and the length at capture (L_c) were larger than size at maturity (L_m) and optimum size for exploitation (L_{opt}) for *Stolephorus devisi*, *Decapterus russelli, Selar crumenophthalmus* and *Megalaspis cordyla.* This indicates that the exploitation of stock is at biologically safer level for these species. *D. russelli* and *S. crumenophthalmus* remain under-exploited and has scope for improved production.

Biological reference points (measurements in cm) of some important pelagic resources in Kerala

Species	L_∞	Mean	Mode	L_m	L_{opt}	L_c	L_{max}
D. russelli	13.5	20.9	19, 21	13.7	13.8	17.2**	24.0
S. crumenophthalmus	17.0	23.6	23, 27	16.7	17.0	19.6**	29.5
M. cordyla	20.0	32.7	23, 33	25.0	26.0	22.4**	40.5
T. lepturus	20.0	69.0	79	47.3	50.9	41.8**	112.0
S. commerson	12.0	68.9	67	70.1	77.1	54.3* (27.6)**	144.0
A. solandri	68.0	81.6	75			70.8*	124.0
E. affinis	36.0	48.8	45	37.7	40.1	39.7*	78.0
A. thazard	22.0	34.6	35	27.5	28.8	28.4*	51.0
A. rochei	16.0	26.8	25, 29	23.6	24.5	24.2*	39.0
R. canadum	24.0		57, 89	70.0	77.0	54.0*	16.0
R. kanagurta	8.0	17.9	15.5, 17.5	17.5	17.9	16.8***	29.5
S. longiceps	5.5	12.7	16.5	14.0	14.1	15.1***	20
S. devisi	7.0	8.3	8.5	6.5	6.3	7.9***	9.5
S. commersoni	7.5	10.3	8.0, 13.5	7.5	7.3	8.5***	15.5

* *Hooks & line/Gillnet,* ** *Trawl* *** *Ring-seine*

The mean size of *R. kanagurta* was larger than the size at maturity (L_m) and same as optimum size for exploitation (L_{opt}). But L_c was slightly lower, necessitating a cautious approach.

In the case of seerfishes, mean size and L_c of *S. commerson* was much smaller than L_m and L_{opt}. Stock assessment shows that the species is heavily exploited. Enforcing minimum legal size for harvest and marketing will help in improving the stock and production. Being a high value resource, capture-based culture (fattening), using the young ones captured by ring seines is another management option. Mean size and

length at capture of *S. commerson* were much smaller than the size at maturity and L_{opt}. Stock assessment shows that the species is heavily exploited and hence exploitation of the resource should be done judiciously.

Length at capture (L_c) was small for *Rachycentron canadum* compared to L_m and L_{opt} indicating stress on the stock. Stock assessment also shows that species is over-exploited, necessitating cautious approach in the exploitation of the resource.

A view of sharks landed by hooks and line at Calicut

Demersal resources

The total demersal fish landings (79,136 t) declined by 8.4% compared to 2009. The major contributors were threadfin breams (42.8%), flatfishes (17.3%), lizardfishes (9.5%), croakers (6.0%), elasmobranchs (4.0%) and groupers (3.1%).

Elasmobranchs: Sharks (64.2%), rays (30.9%) and skates (4.9%) contributed to the elasmobranch fishery. Trawl net, gillnet and hooks and line were important gears that supported the fishery. Thirteen species of sharks were observed in the fishery; *Carcharhinus limbatus* (35.1%), *Carcharhinus sorrah* (14.3%), *Sphyrna lewini* (13.9%), *Sphyrna zygaena* (10.2%), *Carcharhinus melanopterus* (10.7%) and *Alopias vulpinus* (6.8%) were the important species. Hound shark, *Mustelus mosis* was noticed for the first time from the Malabar region.

Fishery related parameters of some important demersal finfish resources in Kerala

Species	Length range (mm)	Mean size (mm)	Fishery dominant size group (mm)	Exploitation ratio (E)	Spawning stock biomass (t)	Standing stock biomass (t)	Yield (t)
C. limbatus	524-2324	1368.2	1200-1800	0.70	40	70	71
N. mesoprion	44-264	-	120-210	0.68	1560	2725	7650
N. japonicus	44-364	141.7	120-240	0.58	1590	2185	4738
C. macrostomus	62-177	116.3	90-140	0.48	2920	5524	5645
J. sina	24-264	141.2	120-180	0.70	909	1400	772
O. ruber	74-334	193.5	160-240	0.72	59	82	180
S. tumbil	185-455	326.0	255-435	0.70	2340	4418	3828
S. undosquamis	105-345	235.0	135-305	0.65	2439	4091	3311
P. hamrur	160-410	279.5	335-305	0.56	-	-	-

Threadfin bream catch by multiday trawlers at Kochi

Threadfin breams: Formed 42.8% of the demersal landings. Bulk of the catch (90.8%) was landed by trawlers. *Nemipterus mesoprion* (61.7%) dominated the fishery followed by *Nemipterus japonicus* (36.5%).

Flatfishes : Formed 17.3% of the demersal landings. Bulk of the catch (97.2%) was landed by trawls. *Cynoglossus macrostomus* was the dominant species both along the Malabar (75.5%) and Central Kerala (78.2%). Other important species were *Cynoglossus dubius*, *C. arel, C. macrolepidotus* and *C. bilineatus*. First record of pelican flounder, *Chascanopsetta lugubris,* from Malabar region was reported during this period.

Sciaenids: Contributed 5.6% of the demersal landings. 36.6% of the catch was contributed by multiday trawlers followed by single day units (28.0%), outboard gillnets (13.2%), ring-seines (4.9%) and others

(17.3%). The fishery was supported by 14 species belonging to four genera. *Johnieops sina* (54.2%) was the dominant species followed by *Otolithes ruber* (10.7%), *J. macropterus* (7.4%), *J. glaucus* (8.1%) and *Nibea soldado* (4.2%).

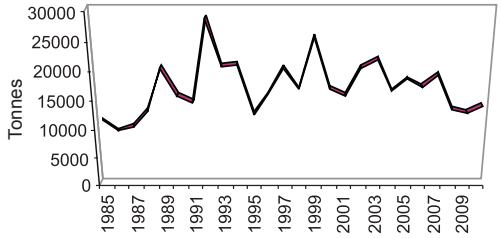
Lizardfishes : Formed 9.5% of the demersal landings. Major share of the catch (81.6%) was landed by multiday trawlers, followed by single day trawlers (6.3%) and outboard gillnetters (1.8%). *Saurida tumbil* (51%), *S.undosquamis* (44%), *Trachinocephalus myops* (3.5%) and *Synodus englemani* (1.1%) were the species which supported the fishery.

Groupers: Formed 3.1% of the demersal landings. They were landed by multiday trawlers (61.1%). *Epinephelus diacanthus* was the most dominant in the fishery followed by *E. epistictus, E. chlorostigma* and *E. longispinis*.

Bull's eye: Formed 4.2% of the demersal landings and were landed by trawlers (70.8%). *Priacanthus hamrur* (86.8%) and *Heteropriacanthus cruentantus* (13.3%) were the species landed.

Pomfrets: Formed 1.7% of the total demersal landings. The major gears that contributed to the fishery were mechanised purse seine (54.6%), trawls (30.5%) and ringseines (11.7%). *Parastromateus niger* (73.8%) was the dominant species followed by *P. argenteus* (25.6%) and *Pampus chinensis* (0.6%).

Catfish: Formed 0.1% of the total demersal landings. The major gears that supported the fishery were trawl nets (50.9%) followed by gillnets (9.1%).



Trends in flatfish landings in Kerala

Management measures

The spawning stock biomass of *C. limbatus* was more than 30% of the annual stock at its unexploited level, which is a good indicator showing the regeneration capacity of the resource.

The exploitation ratio is currently above the optimum level in *N. mesoprion* (E = 0.68) and *N. japonicus* (E = 0.54), but the spawning stock biomass estimated in both species is more than 30% of the stock. This shows that these resources are having sufficient regeneration capacity for the revival of the fishery.

Virtual population analysis carried out on *C. macrostomus* shows that the spawning stock biomass estimated is more than 30 % of the annual stock. This indicates that the resource is also having sufficient regeneration capacity.

Although the sciaenid resources especially *J. sina* and *O. ruber* were heavily exploited, the spawning stock biomass estimated for both the species was more than 25 % of the resource which is a good indicator showing its capacity to revive the future fishery.


Deepsea prawn catch by multiday trawlers at Kochi

Crustacean resources

The total crustacean landing during the year (42,422 t), declined by 23.6% compared to 2009. The major contributors were penaeid prawns (81.3%), stomatopods (7.9%), non-penaied prawns (5.5%), crabs (5.2%) and lobsters (0.1%). 81.2% of the crustaceans were landed by trawlers followed by ringseines (17.2%).

Prawns: Formed 86.9% of the crustacean landings. 93.6 % of the shrimp landings were contributed by penaeids and 6.4% by non-penaeids. Among the inshore penaeid prawns, *Parapenaopsis stylifera* dominated with 61.9% in south Kerala landings. Whereas, *Metapenaeus dobsoni* was the dominant species in central Kerala (84.0%) and Malabar (46.9%).

Fishery related parameters of important prawn species

Species	Length range (mm)	Mean size (mm)	Fishery dominant size group (mm)
M. monoceros	96-170	123.0	110-150
P. indicus	91-180	144.0	120-150
M. affinis	41-150	128.0	120-150
P. stylifera	45-120	84.0	80-120
M. dobsoni	46-120	91.0	80-120
S. choprai	56-100	77.0	70-80

The deep sea penaeid catch was dominated by *Metapenaeopsis andamanensis* (62.4%) followed by *Aristeus alcocki* (37.6%). Among the deep sea non-penaeid prawns, *Plesionika spinipes* contributed 56.0% in south Kerala and 54.2% in central Kerala landings. Other important species were *Heterocarpus gibbossus* (21.0 %) and *H. woodmason* (18.0%).

Crabs: Formed 5.2% of the crustacean landings. 95.9% were landed by trawlers and rest 4.1% by gillnetters. *Portunus pelagicus* (69.4%) accounted for the bulk of the landings in the malabar region, whereas *P. sanguinolentus* was the dominant species in central and south Kerala (47.0%). Other important species were *Charybdis feriatus, C. luciferus* and *Podophthalmus vigil.*

Lobsters : Formed 0.1% of the crustacean landing. 88.0% were landed by trawlers and 12.0% by traps. Slipper lobster, *Thenus unimaculatus* and spiny lobster, *Panulirus homarus* were the most important species landed during the year.

Fishery related parameters of important crabs

Species	Carapace width (mm)	Mean CW (mm)	Dominant size group (mm)
P. sanguinolentus	66-155	98.5	91-100
C. feriatus	46-130	94.5	86-100
P. pelagicus	46-140	105.0	96-110

Molluscan resources

The molluscan landing (32,542 t) was 26.4% more compared to 2009. 71.4 % of the resource catch was by trawlers followed by hooks and lines (17.0%).The major landings were cuttlefishes (46.1%), squids (45.9%), octopus (7.2%) and gastropods (0.8%).

Loligo duvauceli catch by trawls at Calicut

Cuttlefishes: 67.5% of the catch was by trawlers followed by hooks and lines (33.5%). 91.9% of the cuttlefish catch was represented by *Sepia pharaonis.* Other species were *Sepiella inermis* (3.3%) and *Sepia elliptica* (3.1%).

Squids: 81.5% of squid catch was by trawlers, followed by gillnets (6.0%), seine nets (6.2%) and hooks and lines (4.4%). Catch was represented mainly by *Loligo duvauceli* (55.2%). Other species were *L. singhalensis* (23.2%), *L. edulis* (20.2%) and *Sepioteuthes lessoniana* (1.4%).

Status of exploitation of molluscan stocks in Kerala - 2010

Species	Length range (mm DML)	Mean size (mm)	Dominant size group (mm)	Exploitation rate (E)	Spawning stock biomass (SSB t)	Standing stock(t)
			Mechanised Fishing			
Loligo duvauceli	40-390	184	120-150	0.30	17,736	19,664
Sepia pharaonis	40-400	217	270-250	0.37	41,648	61,503
			Artisanal Fishing			
Sepia pharaonis	210-310	307	240-250	0.8	35.7	36.0
Loligo duvauceli	70-190	168	120-130	0.8	45.0	72.0
Loligo edulis	110-330	320	230-240	0.5	434.0	535.0
Perna indica	50-90 (APM)	78	55-60	0.7	398.0	581.0

Octopus catch by trawls at Munambam

Octopus: Formed 7.2% of the total molluscan landings. Almost 99.9% of the catch was by trawlers. Fishery was supported by six species. However, *Octopus membranaceus* (41.9%), *Octopus dollfusi* (38.7%), *Cystopus indicus* (8.5%) and *Octopus lobensis* were the dominant species**.**

Exploitation of molluscan stocks in Kerala during 2010 was mainly of cephalopods and bivalves and was estimated at 32,542 tonnes. Gastropod exploitation was minimal and limited to extreme southwest coast. Among cephalopods, squids and cuttlefishes contributed equally (14,900 tonnes each). Octopus formed less than 10% of the total catch. Generally exploitation rates were within the optimum, except for artisanal fisheries of Vizhinjam, where squid and cuttlefish stocks were over-

exploited. Spawning stocks comprised a healthy percentage of total stocks in all cases. Peak breeding of squid and cuttlefish take place in post-monsoon and recruitment was observed in pre-monsoon.

Economic loss due to juvenile black clam fishing in Vembanad Lake

The black clam (*Villorita cyprinoides*) fishery of Vembanad Lake which contributes to 76% of the total clam landings in Kerala with the involvement of more than 4700 fishers was assessed. From the period 1996-97, the percentage of juvenile clams (below MLS) exploited has shown a steady decrease and this is attributed to use of larger mesh size and awareness of the dangers of exploitation of juveniles by fishers.

The economic loss due to exploitation of the juvenile clams during the 15 year period has been estimated as Rs. 51.3 crores.

New rare species and emerging fisheries of Kerala

The year witnessed the emergence of many new fisheries which were hitherto either rare/sporadic in the catch or were considered a menace in the industry. Puffer fishes which was a menace till recent years, witnessed heavy demand from market and this has resulted in the development of commercial fishery leading to heavy landings of the resource along the coast.

Other major resources for which commercial fishery developed were Indian ruff *Psenopsis cyanea*, Japanese rubyfish *Erythrocles schlegeli*, halfbeaks and unicorn leather jacket, *Aluterus monoceros*.

Species hitherto unknown in the study area and encountered in the landings during the year.

- Blackspot band fish *(Acathocepola limbata)*
- Spinesnout squirrelfish *(Ostichthys acanthorhinus)*
- *Chelidoperca investigatoris*
- Orange banded stingfish *Holapagon maximus (Choridactylus multibarbus)*
- Indian golden barred butterfly fish *(Roa jayakari)*
- Pelican flounder *(Chascanopsetta lugubris)*
- Hound shark *(Mustelus mosis)*

Biological reference points for the black clam stock

Biological Reference Point	Value
Asymptotic Length (L_∞ APM)	56.2 mm
Growth coefficient (K)	0.94
Size at first maturity (SFM)	19.5 mm
Optimum length of Capture (L_{opt})	28 mm
Reproductive Load (SFM/ L_∞)	0.35
Mean generation time (t_g)	0.72 year
Minimum Legal Size (MLS)	20 mm APM
Minimum Legal Weight (MLW)	3.5 g

Percentage of juvenile clams (below MLS) exploited

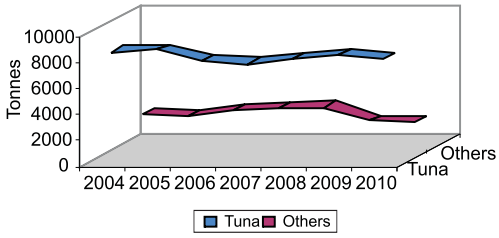
Period	% clams below MLS in fishery	Loss in harvest weights (%)	Economic loss (Rs. Crores)
1996-97	50.73	46	28.00
2000-01	19.53	52	9.00
2002-03	25.79	29	6.70
2009-10	7.97	24	7.60
Total	51.3		

Lakshadweep

Total catch by pole and line, troll line, drift gillnet, encircling gill net and handline was 9,693 t which was 4.8% lesser than 2009.

Tunas formed 81.3% (7,883 t) of the total catch; landings declined by over 4.6 % from 2009. Landings of other fishes and elasmobranchs (1,810 t) declined by 18.7%. Landings at Minicoy, Agatti and Andrott contributed 27.0%, 10.7% and 3.8% respectively to the total Lakshadweep catch. The percentage contribution of the different gears to tuna production were 92.8%, 3.3%, 2.1% and 1.9% respectively.

Puffer fish *Lagocephalus inermis* landed at Munambam by trawler



Estimated tuna and other fishes during 2004-10

Exploited sizes of oceanic tunas in different gears

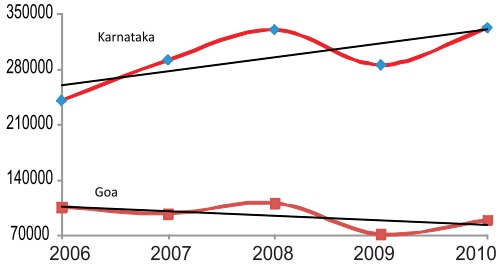
	Size range (Fork length in cm)				
Gears	**P&L**	**TL**	**DGN**	**HL**	**Pooled**
K. pelamis	18-72	28-76	48-74	-	18-76
T. albacares	22-70	26-110	60-120	60-185	22-185

The pole and line landings at Agatti declined drastically; P & L fishing was introduced at Andrott by Agatti fishermen.

Adoption of combination of chumming with live baits and the use of artificial lures and fresh baits and concerted efforts aimed at deep swimming tunas resulted in the increase in the *T. albacares* and *G. unicolor* catches.

The cooked, smoked and dried *Mas* prices which collapsed to Rs 175/kg in 2009 soared to Rs 380-400/kg in 2010.

Karnataka and Goa



Marine fish production of Karnataka and Goa during 2006 – 2010

Karnataka

Trends in the landings of exploited resources: The total marine fish landings in Karnataka showed an increasing trend during the past five years with an all time high of 3.32 lakh t. The catch during 2010 was 16% more as compared to 2009. Tremendous increase in the landings of molluscs especially cephalopods by 118% and pelagic groups (ribbonfishes by 73.7%, carangids by 51.1%, mackerel by 41.8%) as compared to the previous year led to overall increase in marine fish production in Karnataka.

Pelagic fishes dominated the fishery (54.3%), followed by demersal fishes (25.5%) crustaceans (9.4%), molluscs (8.0%) and others (2.8%). Oil sardine followed by mackerel was the most dominant resource at Karnataka and both groups registered an increase in catch during 2010.

Percentage contribution, trend and value of major finfish resources of Karnataka in 2010

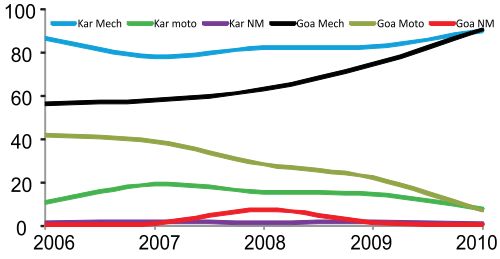
Species/Groups	Catch 2010	% in total	Catch 2009	Trend (%) (+/-)	Value Rs. in lakhs
Oil sardine	64337	19.4	57223	12.4	4503.6
Mackerel	54843	16.5	38,683	41.8	20291.9
Threadfin breams	27558	8.3	30770	-10.4	8267.4
Cephalopods	26252	7.9	12041	118.0	26252.0
Carangids	21916	6.6	14501	51.1	3944.9
Ribbonfishes	17234	5.2	9920	73.7	10340.4
Stomatopods	16811	5.1	14838	13.3	504.3
Lizardfishes	16456	5.0	17051	-3.5	4607.7
Penaeid prawns	12207	3.7	11546	5.7	9155.3
Soles	10646	3.2	6017	76.9	2661.5
Rockcods	7456	2.2	4958	50.4	1491.2
Seerfish	4183	1.3	4407	-5.1	5437.9
Anchovies	4005	1.2	6915	-42.1	801.0

Oil sardine landed in purse seine

The other groups that registered an increase in landings during 2010 were cephalopods, ribbonfishes, stomatopods, penaeid prawns and rock cods. The catch of threadfin breams, lizardfish, seerfish and anchovies declined in 2010. The landings of carangids and soles registered an increase.

Among the major groups landed, mackerel, ribbonfish, seerfish, cobia, whitefish and squilla catch comprised of single species viz., *Rastrelliger kanagurta*, *Trichiurus lepturus, Scomberomorus commerson, Rachycentron canadum* and *Oratosquilla nepa,* respectively. The oil sardine, *Sardinella longiceps* was the dominant (94.8%) species among sardines. Threadfin breams, lizardfishes, carangids, anchovies, tunas, penaeid prawns, crabs and cephalopods were represented by several genera and species.

Gear wise trends in the state: The mechanised, motorised and the non-mechanised sectors contributed 90.7%, 8.1% and 1.2%, respectively to the catch. While production by mechanised sector increased by 27.4%, the production by motorised and non-mechanised sectors registered a steep decline. Trawl net was the major gear and contributed 61.7 % of the catch. The other gears included seines (33.2%) and gillnets (2.9%) operated from motorised and non-mechanised boats.



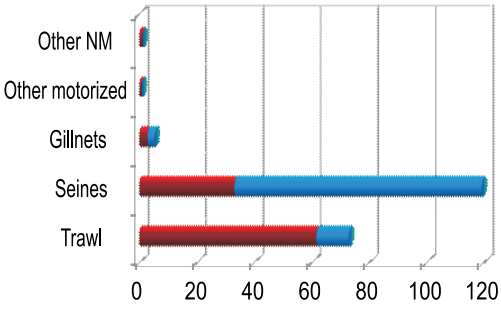
Percentage contribution of mechanised, motorised and non-mechanised sectors to the marine fish production of Karnataka and Goa during 2006- 2010

Gearwise catch rate and major resources contributing to the marine fish production of Karnataka and Goa during 2010

	Karnataka			Goa		
Gear	**Catch (t)**	**%**	**c/e (kg)**	**Catch (t)**	**%**	**c/e (kg)**
Trawls						
Multiday	167345	50.4	44.7*	7817	8.7	23.5*
Single day	37802	11.4	56.0*	2315	2.6	29.4*
Seines						
Purseseine	92900	28.0	2218.0	72514	81.1	3834.1
Ringseine	17417	5.2	2042.0	7179	8.0	1455.6
Gillnets						
Mechanised GN	3509	1.1	129.5	0	0	0
Motorised GN	6221	1.9	105.6	2225	2.5	81.9
Others (motorised)	3005	0.9	531.0	0	0	0
Others (non-mechanised)	4112	1.2	26.8	401	0.4	30.3

*Catch/hr, c/e= catch/unit

An increase in the landing by purseseines was observed by 43.7% during the year. Introduction of very large purseseine units with fish holding capacity ranging from 12 to 20 t, use of high speed engines (>300 hp) and multiday operations are the main reasons for increased production by the gear. Further, purseseines targeted mackerel in the nearshore as well as deeper waters and seerfish and tunas in the deeper waters using large meshed heavier fast sinking nets. The trawl catch registered an increase of 27.4%, but the catch by gillnets declined by 59.9%.



Contribution of different gears to total marine fish production of Karnataka and Goa

Length distribution, sex ratio, maturity and food of 45 species exploited by major gears along Karnataka coast were studied. In most of the species the mean length of exploitation was found to be higher than the length at first maturity. Growth and stock parameters of 24 dominant species were estimated. The exploitation ratio' was higher than desired levels in most species except *A. thazard, P. sanguinolentus, M. monoceros, P. stylifera* and *S. pharaonis.*

Soles ready for auction at Mangalore Fisheries Harbour

Metapenaeus monoceros

Length distribution, sex ratio and maturity of different species exploited by major gears along Karnataka and Goa coast

Species	Length range (cm)	Mean (cm)	Sex ratio
Trawl			
S. longiceps	10.5-20.5	16.6	1.0:1.2
S. fimbriata	12.0-19.5	15.6	1.0:1.5
S. gibbosa	13.5-20.0	17.2	1.0:0.6
S. albella	13.0-16.5	14.8	1.0:1.8
R. kanagurta	5.0-27.5	20.2	1:0.94
T. lepturus	26.0-112.0	65.0	1:0.94
D. russelli	7.0- 29.5	10.6	1:0.95
M. cordyla	10.0-46.0	25.1	1:0.85
E. devisi	6.2-10.6	8.5	1:0.9
S. waitei	7.0-11.6	9.2	1:0.9
R. canadum	27-135	61.0	1:1.64
S. commerson	12.0-80.0	34.0	
N. mesoprion	4.0-29.0	12.0	1:0.7
N. japonicus	6.0-35.0	13.7	1:0.6
L. lactarius	5.0-29.0	15.0	1:1
C. macrostomus	5.5-17.5	12.7	1:0.8
I. omanensis	23-71	43.0	1:0.6
S. laticaudus	27-92	51.0	1:0.7
C. limbatus	48-118	73.0	1:1.4
S. lewini	28-84 &198-283	52.0	1:1.1
R. acutus	39-56	48.0	1:9
H. bleekeri	15-57	28.0	1:1.5
M. eregoodootenke	52-242	153	1:1.3
R. javanica	20-58	29	1:1.2
P. sephen	16-138	46	1:0.4
H. uarnak	20-124	50	1:0.3
R. halavi	16-54	24	1:1.2
R. ancylostoma	24-211	68	1:1.25
R. annandalei	16-30	22	1:0.9
P. stylifera	5.6-11.5	8.4	1:1.1
M. dobsoni	5.3-11.0	7.8	1:0.8
M. monoceros	9.1-18.5	12.4	1:1.06
S. choprai	5.1-11.0	8.0	1:1.29
P. pelagicus	4.6-14.5	8.9	10.79
P. sanguinolentus	5.6-13.0	8.9	1:0.69
C. feriatus	4.1-12.0	6.7	1:0.81
S. pharaonis	40-350	143	1:0.9
S. elliptica	50-160	74	1:1.1
S. prashadi	80-160	113	1:0.9
S. inermis	20-110	58	1:0.9
L. duvauceli	10-310	117	1:0.7
L. singhalensis	50-310	123	1:0.3
L. edulis	60-350	167	1:0.9
O. membranaeus	20-90	56	1:0.8
Purseseine			
S. longiceps	8.5-20.5	14.7	1.0:1.0
R. kanagurta	4.0-27.0	13.3	1:1.12
D. russelli	11.5-22.0	18.5	1:0.6
D. macrosoma	13.2-20.5	17.5	1:1
E. devisi	6.6-9.6	8.7	1:2.29
S. commerson	30.0-62.0	53.0	
Gillnet			
R. kanagurta	13.0-26.5	21.2	1:0.62
S. commerson	36.0-112.0	64.0	1:1.2

M. cordyla	18-44	31.5	1:0.94
T. tonggol	28.0-62.0	43.0	1:1.4
E. affinis	18.0-60.0	41.0	1:1.6
A. thazard	20.0-48.0	35.0	1:1.2
A. rochei	18.0-32.0	23.0	1:3
T. albacares	33.0-37.0	33.0	1:1
K. pelamis	30.0-41.0	35.0	1:0.4
Ringseine			
R. kanagurta	17.5-22.5	20.1	1:1.2
M. dobsoni	6.5-12.5		1:1.3

Goa

Trends in the landings of exploited resources: The marine fish production in Goa showed a declining trend over the years with the annual catch varying from 71,391t (2009) to 1,10,508 t (2008). However, the catch (89,451 t) during 2010 is 25.3% more than the catch recorded during 2009. Increased landings during the year were due to increase in landings of rock cods and mackerel, respectively as compared to the previous year.

Percentage contribution, trends and value of the exploited finfish resources of Goa in 2010

Species/Groups	Catch 2010	% in total	Catch 2009	Trend (%) (+/-)	Value ' in lakhs
Oil sardine	16172	18.1	27930	-42.1	1132.0
Mackerel	46871	52.4	11795	297.4	17342.3
Threadfin breams	1841	2.1	3539	-48.0	552.3
Cephalopods	1516	1.7	905	67.5	1516.0
Carangids	5953	6.7	6517	-8.7	1071.5
Ribbonfishes	1362	1.5	841	62.0	817.2
Stomatopods	549	0.6	249	120.5	16.5
Lizardfishes	78	0.1	551	-85.8	21.8
Penaeid prawns	3646	4.1	2095	74.0	2734.5
Tunas	2493	2.8	1848	34.9	623.3
Rockcods	2335	2.6	350	567.1	467.0
Seerfish	334	0.4	1460	-77.1	434.2
Anchovies	4	0.0	63	-93.7	0.8

Pelagic fishes dominated the fishery (82.8%) followed by demersal fishes (10.4%), crustaceans (4.9 %), and molluscs (1.8%). The major groups/species that contributed to the marine fish catch in Goa included oil sardine, mackerel, threadfin breams, cephalopods, rockcods, lizardfish, penaeid prawns and carangids. Mackerel followed by oil sardine formed the major resource.

While the catch of mackerel registered an increasing trend, oil sardine registered a negative trend. The other groups that registered an increase in landings were cephalopods, ribbonfishes, stomatopods, penaeid prawns and rock cods. The catch of threadfin breams, lizardfish, seerfish and anchovies declined in 2010 as compared to 2009. Carangid landings registered a decline, while the tuna catch increased.

Gear-wise trends in the state: The mechanised, motorised and the non mechanised sectors contributed 92.4%, 7.2% and 0.4%, respectively to the catch in Goa. While production by the mechanised sector increased by 17.1%, the production by the motorised and non-mechanised sectors registered steep decline. The purseseine was the dominant gear

Squids landed by bull-trawlers

Notable changes observed in the fishing pattern during the study period

- *Lagocephalus inermis considered a menace is now commercially harvested.*
- *Large sized fishing vessels with OAL >23.3 m introduced.*
- *Full fibre body mechanized trawlers and purseseiners introduced.*
- *Several new fishmeal and surumi plants established leading to high demand for trash fishes.*
- *Quantity of trash landed has increased and discards (low value fish thrown back into the sea) minimized or nil.*
- *Fishing duration of 10-12 days reduced to 6-7 days and no. of hauls per trip increased.*
- *Conflicts on the right to fish in the traditional grounds between trawlers and purseiners as well as units with speed engine and without are on the rise.*

contributing to 86.2% of the total catch followed by trawls (11.3%) and gillnets (2.5%). An increase in the landing by purseseines was observed by 33.3%.

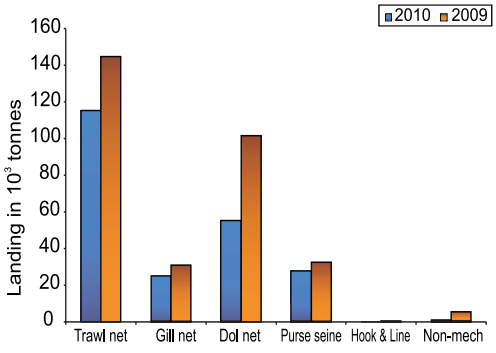
The trawl catch registered a decrease of 4.5% during 2010 in comparison to 2009. The catch by gillnets increased by 129.5%.

Growth and stock parameters of dominant species along Karnataka and Goa

Name of species	L_m(cm)	L_∞ (cm)	K/yr	t_o	L_{opt}(cm)	M	Z	E
R. kanagurta	17.5	31.8	1.1	-0.0833	19.6	2.10	8.75	0.76
S. longiceps	15.0	22.8	0.9	-0.1124	13.8	1.79	5.40	0.67
E. devisi	6.8	11.7	1.59	-0.0660	6.9	2.81	15.7	0.82
S. waitei	8.0	11.5	1.5	-0.0728	6.8	2.67	8.99	0.70
M. cordyla	25.0	49.6	0.7	-0.1117	31.1	1.49	3.70	0.60
S. commerson	70.0	162	0.78	-0.0742	106.7	1.61	6.43	0.75
D. russelli	16.0	28.4	0.7	-0.1302	17.4	1.49	6.29	0.76
E. affinis	43.0	79.0	0.89	-0.0807	26.8	1.78	4.77	0.63
A. thazard	30.5	49.0	0.96	-0.0855	30.7	1.88	3.34	0.44
T. lepturus	60.0	134	0.86	-0.0720	87.6	1.78	6.03	0.70
N. mesoprion	18.2	31	0.78	-0.1170	19.1	1.78	4.52	0.61
N. japonicus	19.5	33.5	0.89	-0.1021	20.7	1.78	6.95	0.74
C. macrostomus	11.1	17.8	0.95	-0.1142	10.7	1.86	6.70	0.72
L. lactarius	17.2	29	1.0	-0.0948	17.8	1.94	4.84	0.60
M.dobsoni	7.1	11.9	1.2	-0.0984	7.0	2.20	6.13	0.64
M. monoceros	11.6	12.3	1.5	-0.0714	7.3	2.80	6.17	0.55
P. stylifera	8.35	19.2	1.4	-0.0701	11.6	2.80	6.56	0.57
S. choprai	6.5	12.0	1.2	-0.0982	7.1	2.23	6.10	0.63
P. sanguinolentus	9.6	16.9	1.9	-0.0432	10.1	2.9	2.15	0.43
P. pelagicus	8.96	17.3	1.3	-0.0800	10.4	2.5	3.58	0.62
C. feriatus	7.1	13.5	1.2	-0.0951	8.0	2.2	4.21	0.66
L. duvaucelli	24.0	42.1	0.9	-0.0949	26.2	0.82	6.31	0.87
S. elliptica	11.0	17.7	0.85	-0.1369	10.6	1.0	5.77	0.83
S. pharaonis	24.0	42.0	1.2	-0.0696	26.1	2.23	5.5	0.59

Length distribution, sex ratio, maturity and food of 45 species exploited by major gears along Goa coast were studied. In most of the species, the mean length of exploitation was found to be higher than the length at first maturity. Growth and stock parameters of 24 dominant species were estimated. 'Exploitation ratio' was higher than desired levels in most species except *A. thazard, P. sanguinolentus, M. monoceros, P. stylifera* and *S. pharaonis.*

Maharashtra



Comparison of gear-wise landings in 2009 and 2010

The marine fish landings in Maharashtra during 2010 have been estimated provisionally at 2.25 lakh t of which major share came from trawling sector (51.4%) followed by *Dol net* (24.6%), Purse seine (12.4%), Gillnet (11.2%), hooks and lines (0.02%) and non-mechanized sector (0.5%). When compared to 2009, the total marine fish landings showed 29% decline while total number of units landed and the actual fishing hours showed 33.5% and 22.3% decline respectively.

The value of the total catch at first point of sell has been estimated at Rs 2,215 crores. Despite decline in landings by 29%, the revenue improved by 46% as compared to 2009 (Rs 1,519 crores) as the average price of fish showed steep rise from Rs 48/kg to 111.8/kg. Major share of the revenue came from trawling (71.3%) followed by '*dol*' netting

(15.0%), gill netting (8.2%), purse seining (5.3%), hooks and line fishing (0.02%) and non-mechanised fishing (0.3%).

The major resources landed during the year were non-penaeid prawns (15.6%), penaeid prawns (12.2%), mackerel (9.7%), croakers (8.4%), clupeids (8.0%), cephalopods (6.8%), threadfin breams (6.6%), Bombayduck (5.2%) and carangids (4.3%). Other commercially important resources were elasmobranchs (3.5%), tuna and billfishes (2.3%), seerfishes (1.9%) and pomfrets (1.4%).

The estimated landing by trawlers was 1.16 lakh t by expending 3.98 million trawling hours at the catch rate of 963 kg/trip (29.2 kg/hr). Multi-day trawlers contributed to the bulk (82.8%) while single day trawlers and hand operated trawlers constituted 17.2% of the catch. The major fish components of trawlers were penaeid prawns (21%), croakers (13.8%), threadfin breams (12.8%), cephalopods (12.5%) and ribbonfishes (10.6%).

The bag netters landed 55,286 t by expending 2,07,708 boat-trips (0.499 million hauls) at the catch rate of 266 kg/trip (110.7 kg/haul). The major constituents of bag nets were non-penaeid prawns (57.2%), followed by Bombayduck (14.8%), golden anchovies (6.5%), penaeid prawns (4.8%) and pomfrets (2.7%).

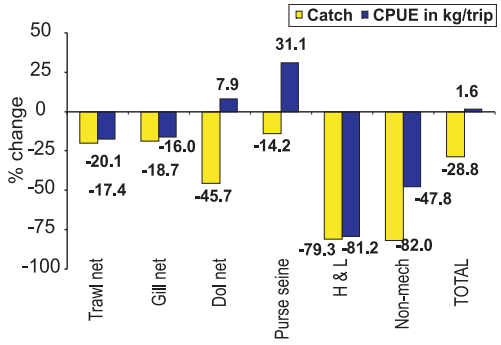
The gill netters landed 25,242 t by expending 224,098 boat-trips (1.97 million hours) at the catch rate of 112.6 kg/trip (12.8 kg/haul). The major constituents of gill nets were mackerel (23%), followed by seer fishes (13.2%), carangids (9.0%), clupeids (8.9%), catfishes (8.4%), tuna and billfishes (8.1%) and pomfrets (2.4%).

The purse seiners landed 27,830 t by expending 13,470 boat-trips (87,353 hours) at the catch rate of 2,066 kg/trip (319 kg/hour). The major constituents of purse seine nets were mackerel (50.6%), followed by carangids (14.9%), catfishes (13.2%), tuna and bill fishes (9.6%) and clupeids (8.4%). The abundance of Indian mackerel (*Rastrelliger kanagurta*) was exceptionally high all along the coast of Maharashtra. As a result not only 'Rampani, fishery in southern districts of Sindhudurg and Ratnagiri was once again abuzz after a gap of many years, but most of the shrimp trawlers also took to purse seining to catch this fish. Estimated landing of mackerel during the year was 21, 761 t that contributed to 18.8% of the total marine fish landings next only to prawns (54%).

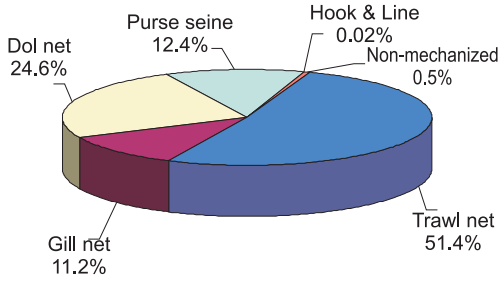
The hooks and line fishery in the state which is dwindling year by year, survived due to increased hooking (jigging) of squid *Loligo duvauceli*. The estimated landings from hooks and line fishery were 56 t and almost the entire catch was constituted by squids (94.6%) followed by catfishes (1.8%) and elasmobranchs (1.8%).

The non-mechanized fishery with indigenous gears such as shore seines (*rampani*), gillnets (*Disco nets*), inshore bag (*bokshi*) nets, cast nets, barrier nets and hooks and lines landed 1,021 t of fish at the catch rate of 49.2 kg/unit. The catch was mainly constituted by mackerel (60.2%) and non-penaeid prawns (15.8%).

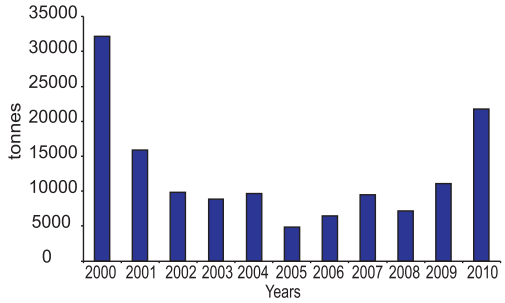
Penaeid prawns was the single largest resource that contributed 21% to the total fish catch in trawlers. At New Ferry Wharf and Versova, the



Gear-wise percentage change in catch and catch rate in Maharashtra compared with 2009



Gear-wise composition of fish landings in Maharashtra



Gear-wise landings of Indian mackerel in Maharashtra during 2000-2010

catch and the catch rate recorded 8% and 16.5% decline when compared to 2009. *P. stylifera* was the most dominant species (39.7%) followed by *M. affinis* (18.8%) and *S. crassicornis* (17.8%). During the year significant decline in catch of *P. hardwickii* (52%), *P. sculptilis* (28%), and *M. affinis* (28%) were recorded.

The landings of Bombay duck was estimated at 11, 710 t during the year.

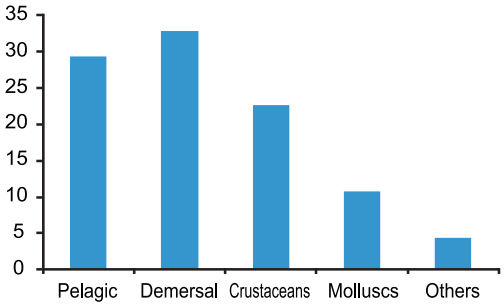
Analysis of marine fisheries 1997-2007 data showed potential of 2.53 lakh t of small pelagics, 0.19 lakh t of large pelagics and 2.45 lakh t of demersal resources. Maharashtra has a peculiar *dol* net fish assemblage comprising of Bombayduck, *Coilia*, non-penaeid prawns and ribbonfishes (BCNR community) with a potential of 1.65 lakh t. Accordingly, with total potential yield at 5.18 lakhs t the optimum fleet size is estimated at 8,783 fishing boats for the management and sustainability of the exploited marine fishery resources in Maharashtra. The Schaefer's model for the target resource (shrimps) indicated 47% reduction while potential yield suggested 50% reduction of trawling fleet in the state.

A disastrous accident of collision of two ships took place on 7th August 2010 in Mumbai Harbour spilling in the sea about 800 t of furnace oil and 300 shipping containers some of which had hazardous chemical and pesticide cargo. The oil spill directly caused fish mortality in the vicinity and most of the mangrove area around the harbour was thickly smothered with it. The mongroves served as nursery for juvenile fishes and prawns that are recruited to the fishery in post-monsoon fishing season. The oil spill had indirect effect on the fish price as people stopped eating fish for about a month and the prices plummeted. However, in subsequent months the fish prices soared due to scarcity of marine fish.

Long-term Potential Yield (LTPY) and fleet size in Maharshtra

Resource/Yield	Present (tonnes)	Potential (tonnes)
Demersals	168130	245184
Large pelagics	12691	19014
Small pelagics	171261	253926
Total	352082	518124
Fleet size in numbers	**Present**	**Optimum**
Trawlers	4219	2042
Dol nets	4409	3758
Gill netters	2550	2129
Purse seiners	156	120
Motorised	3382	235
Hook & line boats	253	35
Non-mech. crafts	7073	No restriction
Others	1466	
Total	**23,508**	**8,319+**

Gujarat



Percentage contribution of different groups in marine fish landings of Gujarat during 2010

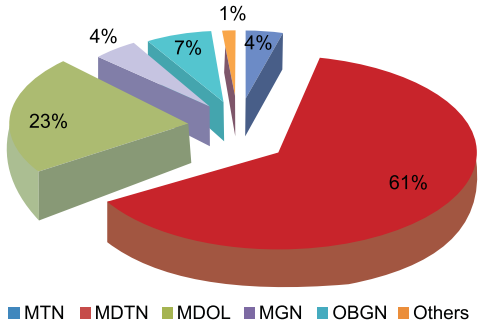
The estimated marine fish production from Gujarat in 2010 was 5.06 lakh t showing a marginal decrease of 0.3% from that of previous year. The landings of demersals was 1.7 lakh t forming 32.8% of landings and pelagics 1.15 lakh t forming 29.4%. Crustaceans formed 22.7% (1.15 lakh t), molluscs, 10.7 % (0.54 lakh t) and others 4.4% (0.2 lakh t). The maximum landings were that of non-penaeid prawns (68,504 t) followed by ribbonfishes (54,300 t), sciaenids (44,765 t) Bombayduck (37,879 t) and catfishes (33,074 t). There was a decrease in demersals landings and increase in pelagics and molluscan landings compared with the previous year.

Gear-wise landings indicate that mechanised multi-day trawlers (MDTN) contributed 61% of the total fish landings followed by mechanised dolnetters (MDOL - 23%). Outboard gillnets (OBGN) contributed 7%, single-day trawlers (MTN) and mechanised gillnets (MGN) 4% each and other gears 1% of the total landings.

Under pelagics, ribbonfishes formed 37%, Bombayduck, 25%, carangids 9%, seerfish and tunas 6% each.

Under demersals, the most important group was croakers (27%) followed by perches (25%), catfish (20%), lizardfishes (7%), elasmobranchs (5%) and pomfrets (4%).

The major group landed by mechanized dolnet was crustaceans (41%) followed by Bombayduck (31%) and catfishes (10%).

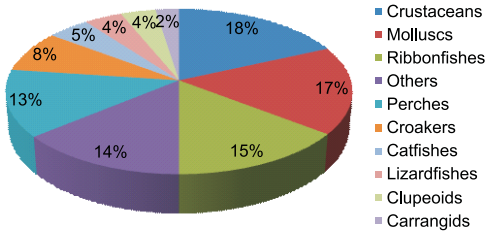


Gear-wise contribution to total landings of Gujarat in 2010

Resource-wise fishery and biology

Pelagic resources

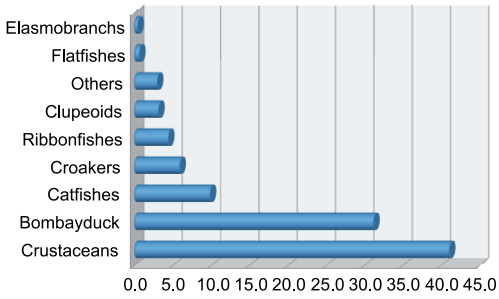
Bombayduck (*Harpadon nehereus*)**:** The estimated total catch of Bombayduck in Gujarat during 2010 was 37,879 t (7.5% of the total fish landing). The landings by dolnets from the inshore grounds of Nawabunder, Rajpara and Jaffrabad were 25,178 t, which is nearly 22% of the total dolnet catches with a catch rate of 742.2 kg/unit. Higher catch and catch rates were seen during October - December. The size of *H. nehereus* ranged from 180 to 309 mm with a mean of 229 mm and distinct modes at 187, 217, 267 and 247 mm. A sex ratio of 1:1.9 was recorded with high proportion of immature females occurring during January-March and gravid/spent females during September-November. The relative fecundity was 282/g body weight with ova diameter ranging from 0.18 mm to 0.9 mm. Bombayduck feed mainly on non-penaeid and penaeid prawns and juveniles of many fish species.



Percentage contribution of different groups of fishes in the multi-day trawlers in Gujarat during 2010

Ribbonfish: The estimated ribbonfish landing in 2010 was 54,300 t, forming 10.7% of the total landings. Mechanised multi-day trawlers alone contributed 82% of the ribbonfish landing and the remaining by single day trawlers, mechanized dolnetters and gillnetters. Contribution by trawlers at Veraval alone was 27,500 t with the catch rate of 15.6 kg/h. The catches and catch rates were significantly higher during the post monsoon months. *Trichiurus lepturus* was the single species with size ranging from 50 to 109 cm (mean: 70) and having a sex ratio of 1: 2.3 with equal distribution of mature (47%) and immature females (44%) occurring throughout the year. Relative fecundity was 238/g body weight. The principal food components were *Acetes*, cephalopods, juveniles of sciaenids, ribbonfishes and other teleosts and digested fish.

Seerfishes: The seerfish landing is estimated to be 9,057 t. Outboard gillnets and multiday trawlers contributed 48% and 23% respectively of the landings. The landing by gillnets at Veraval was 446 t with the catch rate of 35.5 kg/unit supported by *Scomberomorus guttatus* (69.2%) and *S. commerson* (30.8%). The size of *S. guttatus* ranged from 220 to 599 mm with distinct modes at 470 mm. Mean annual length was 343.5 mm. Sex ratio was 1:1.42 in the catch with majority of them in the immature state. The relative fecundity was 178/g body weight. The analysis of food components revealed preference of clupeoids, mackerel and tunas.



Percentage contribution of different groups of fishes landed by mechanised dolnetters in Gujarat during 2010

Tunas: The annual catch of tuna was 8,840 t caught by outboard gillnetters (60%) and mechanised multiday gillnetters (36%). The species landed were *Thunnus tonggol* (48%), *Euthynnus affinis* (31%), *Auxis thazard* (14%), *Katsuwonus pelamis* (6.2%), and *Thunnus albacares* (1.2%). The length ranges recorded for *Thunnus tonggol*, *Euthynnus affinis* and *Katsuwonus pelamis* were 320 to 659 mm, 400 to 659 mm and 380 to 619 mm, respectively with mean lengths of 565.2 mm, 517 mm and 476 mm. Females outnumbered males in *T. tonggol*, *E. affinis*

Bombayduck kept for drying

and *K. pelamis* in most of the months. Relative fecundity of *E. affinis* and *K. pelamis* was between 169 and 136/g body weight. Clupeoids, ribbonfishes, mackerel, tunas, carangids, cephalopods, digested fish and shrimps were the principal food constituents of tunas.

Carangids: The annual estimated landing of carangids was 13,927 t forming 3% of the total marine fish landings. Multiday trawlers (55%) and outboard gillnetters (33%) contributed maximum of the carangid landings. Among carangids, *Megalaspis cordyla* dominated the gill net catches (50%) while *Decapterus russelli* dominated the trawl landings (60.5%). The size ranges recorded for *M. cordyla* were between 220 to 449 mm. Sex ratio was 1: 1.3 in *M. cordyla* with 50% being immature. The relative fecundity of females of *M. cordyla* were 458.5/ g body weight.

Mackerel: The estimated mackerel landings was 1,758 t. Outboard gillnetters (60%) and mechanised multiday gillnetters (34.4%) contributed the major share of mackerel landing. The catches and catch rates were significantly higher during the post monsoon months. *Rastrelliger kanagurta* was the sole species with size ranging from 120 to 279 mm (mean: 237.2 mm) and a sex ratio of 1:0.6 with mature (60%) and immature (37%) females occurring throughout the year.

Length ranges and reproductive biology of pelagic species landed in Gujarat

Species	Length range (mm)	Mean Length (mm)	Sex Ratio	Mature %	Fecundity per g body weight	Ova dia (mm)
Harpadon nehereus	180-309	229	1.89	10.75	349.26	0.18-0.78
Trichiurus lepturus	500-1090	700	2.30	33.00	101.44	0.18-1.83
Scomberomorus guttatus	220-599	343.50	1.42	54.40	116.65	0.15-1.33
Thunnus tonggol	320-659	565.16	2.36	18.76	56.82	0.18-0.8
Euthynnus affinis	400-679	521.80	1.90	35.21	209.65	0.18-1.05
Katsuwonus pelamis	400-619	475.9	1.38	34.72	82.8	0.18-1.00
Megalaspis cordyla	220-449	327.6	1.33	28.2	152.92	0.15-0.98
Rastrelliger kanagurta	120-279	237.2	0.60	59.7	154.37	0.15-0.78
Rachycentron canadum	340-1239	692.0	1.29	28.57	-	-

Cobia: The estimated cobia landings by trawlers and gill netters in Veraval were 19.1 t and 64.6 t, with an average catch rate of 0.03 kg/h and 5.15 kg/unit respectively. The cobia landing increased over the previous year by 51.3%.

Threadfin breams: The landings by multiday trawlers in Veraval was 12,259 t at catch rate of 6.92 kg/h. Catch was moderately high after the post-monsoon season. The landings increased by 11.3% while comparing with the previous year. Fishery was dominated by *Nemipterus mesoprion* (48.4%) *N. japonicus* (41.9%), and *N. delagoe* (9.7%). The length of *N. japonicus* ranged between 126 and 296 mm (mean 206.8 mm) and the length of *N. mesoprion* was between 104 and 260 mm (mean 176.3 mm) with a distinct mode at 181 mm. Females outnumbered males in the population. Immature individuals were highly represented in the population of *N. mesoprion,* and in *N. japonicus* majority of them were in mature condition. Stomach analysis revealed an abundance of non-penaeid and penaeid prawns with other major food items like *Solenocera, Acetes, Loligo and* silverbellies in both the species.

Lizardfishes: Estimated lizardfish catch in Gujarat was 12,699 t. At Veraval, 6,596 t was estimated to have been caught by trawlers at a catch rate of 3.72 kg/h forming 4.7% of the total landings of Veraval region. The catch rate was moderately high during the post-monsoon season with relatively higher catch observed during December. The main species contributing to the fishery were *S. tumbil* (72.2 %) and *S. undosquamis* (27.8%). *S. tumbil* was in the length range of 132-412 mm (mean length: 279.4 mm) with a mode at 274 mm and *S. undosquamis* in the length range of 178-387 mm (mean 247 mm). Females dominated throughout the year with a majority in immature condition.

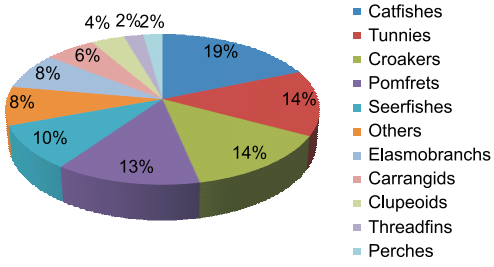
Sciaenids: The estimated sciaenid catch was 44,765 t which declined by 7.6%. The species composition in trawl fishery was *Otolithes cuvieri* (38.4%), *Johnius glaucus* (38%), *Johneops* sp. (19.8%), *Otolithoides biauritus* (3.2%) and *Protonibea diacanthus* (1.2%). Though the species composition in the gill net and dolnet represented the same pattern as in trawlers, the percentage of *O. biauritus* and *P. diacanthus* were comparatively higher. Length of *O. cuvieri* ranged from 184 to 380 mm (mean:256.2 mm) with a mode at 242 mm while for *J. glaucus* the length varied from 206-247 (mean:215.2 mm) with a mode at 213 mm . Majority of *O. cuvieri* and *J. glaucus* were either in mature or in gravid condition.

Bull's eye: The landings of priacanthids by trawlers was 2,221.3 t dominated by *Priacanthus hamrur* at catch rate of 1.25 kg/h. The catch rate declined by 3.9%. The length of *P. hamrur* ranged between 154-387 mm (mean 237.3 mm). There was a preponderance of females in all months except in January, May, September and December. A sex ratio of 1:1.3 was recorded throughout the year with immature forming 19.5%, mature 38.8% and gravid/spent 40.6%.

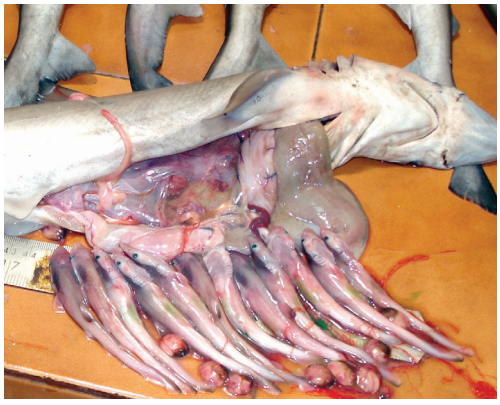
Pomfret: The estimated pomfret production was 4,825 t. The total pomfret landings by trawlers was 65.2 t with a catch rate of 0.04 kg. The gill net production was 26.6 t with a catch rate of 9.3 kg. The pomfret catch decreased by 71% . The length of *Pampus argenteus* ranged between 154-535 mm (mean: 233 mm) with a mode at 222 mm. There was a preponderance of females in all months except in March. Mature fishes formed 54.7%, immature 36.6% and gravid and spent 8.7% in the population.

Catfish: Catfish landing was 33,074 t which showed declining trend by 7.6%. The estimated catch of catfish by trawlers in Veraval was 4,122 t with a catch rate of 2.33 kg which formed 2.73% of the total catch. The length range of *Arius tenuispinis* ranged between 310 and 562 mm (mean: 397.7 mm). The sex ratio (1:3.5) showed that females were dominant in all months except April, with the occurrence of immature and mature ones in the population.

Elasmobranchs: The estimated catch of elasmobranchs was 8, 641 t which composed mainly of sharks (69.4%). The total elasmobranch landings was estimated at 975.7 t with a catch rate of 0.55 kg along Veraval coast. The fishery showed an upward trend (3.74%) compared to the previous year. The major catch was by trawl net (89.4 %) and gillnetters contributed the rest (10.6%). The dominant species in the trawl fishery was *Scoliodon laticaudus* (43.1%), *Carcharinus* sp. (7.32%), *Mobula* sp. (0.38%), *Sphyrna* (0.73%) and *Dasyatis* sp. (17.36%) and in gillnet fishery *Scoliodon* 57.3%, *Carcharinus* 14.2%, *Sphyrna* 13.9% and *Mobula* 12.9%. The length range of *Scoliodon* ranged from 262 to 600 mm (mean: 462.8 mm).



Percentage contribution of different groups of fishes landed by mechanised gillnetters in Gujarat during 2010



Young ones of a shark landed in Gujarat

Length range and reproductive biology of demersal species landed in Gujarat

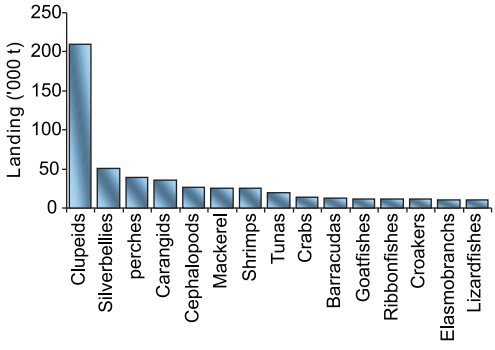
Species	Length range (mm)	Mean Length (mm)	Sex Ratio	Mature %
Nemipterus mesoprion	104-260	176.3	1.6	44.2
Nemipterus japonicus	126-296	206.8	1.8	65.7
Saurida tumbil	132-412	279.4	3.2	25.4
Saurida undosquamis	178-387	247.1	2.4	35.5
Priacanthus hamrur	154-387	237.3	1.3	38.8
Johnius glaucus	206-247	215.2	3.3	66.8
Otolithes cuvieri	184-389	256.2	3.4	47.6
Pampus argenteus	154-535	233	1.6	54.7
Scoliodon laticaudus	262-600	462.8	2.7	16.9
Arius tenuispinis	310-562	397.7	3.5	30.4

Molluscan resources

The percentage of squids in molluscan landings was 54%, cuttlefishes 45% and octopus formed the rest.

Cephalopods: The total cephalopod production was estimated to 54,355 t composed of squid (54.3%), cuttlefish (45.1%) and octopus (0.6%). The cephalopod production in Veraval by multiday trawlers was 26,442 t at a catch rate of 16.1 kg/h forming 18.9% of the total catch. The catch showed an upward trend of 42% while comparing with the previous year. The order of abundance in catch composition was *Loligo* sp. (59.4%), *Sepia* spp. (26.2%), *S. pharoanis* (12.3%), *S. inermis* (1.78%) and *Octopus* sp (0.8%). The catch and catch rates were the highest in the last quarter. *Loligo duvauceli* dominated the catches with a length range of 35-282 mm and mean length of 128.1 mm. Immature ones were found to be dominant and mature and gravid females were equally represented in the population.

Tamil Nadu and Puducherry



Group-wise landings of Tamil Nadu in 2010

The total marine fish production in Tamil Nadu during the year 2010 was 5.55 lakh tonnes. The mechanised sector contributed 65% to the total landings, motorised sector 34% and the non-mechanised sector only 1%. Trawl landings formed 59% of the total landings, with 52 kg per hour. Fishes formed 85% of the total landings, crustaceans 7% and molluscs 5%. Clupeids contributed 38% to the total landings; the oil sardine (1.14 lakh tonnes) was dominant with 54% of the landing of clupeids. Drift gillnets contributed 32% to the oil sardine landings, trawlnets 29% and seines 15%. Silverbellies were the next dominant group, contributing 9% to the total landings. Indian mackerel contributed 5% to the total landings.

Analysis of landings data for the period from 2006 to 2010 showed that the annual landings in Tamil Nadu increased from 3.62 lakh tonnes in 2006 to 5.55 lakh tonnes in 2010. Oil sardine, silverbellies and other sardines remained the top three contributors during the period.

The total landing at Puducherry was 14,525 t, of which 41% was landed by trawlers. The mechanised sector contributed 44.8% to the total landings, motorised 55.1% and the non-mechanised sector 0.1%. At Puducherry also, the oil sardine was dominant in the landings. A total

of 3,541 t of oil sardine was landed, of which 64% was by ringseines, 21% by purseseines and 15% by gillnets. *Thryssa* spp., penaeid shrimps and Indian mackerel were the other dominant resources, forming 9.0%, 8.7% and 7.0% of the total landings.

Biological Studies

Biological studies were carried out on major species landed at Chennai, Tuticorin, Mandapam and Kanyakumari. Estimates of growth parameters, spawning seasons and yield of major fish species landed at Chennai were made using data compiled during 2006-2009.

Stock estimates for 11 species of demersal finfishes off Chennai

Species	Length range (mm)	Mean Length (mm)	L_∞ (mm)	K/yr	F	M	Z	F/Z	Length at first maturity (mm)	Peak spawning period	Fecundity
Nemipterus japonicus	70-279	152.1	271	0.81	0.92	1.66	2.58	0.36	133	October-April	38400-40270
Nemipterus mesoprion	70-199	140.8	232	0.86	1.64	1.73	3.37	0.49	120	August-October	17250-28400
Nemipterus bleekeri	70-259	154	267	0.45	0.35	1.13	1.48	0.24	125	March-September	46220-48500
Otolithes ruber	100-399	430	175.4	0.33	0.98	1.03	2.01	0.49	180	October-April	43920-44610
Johnius carutta	100-259	280	167.9	0.76	2.19	1.59	3.78	0.58	155	August-October	15340-17130
Nibea maculata	100-259	280	207.9	0.82	0.23	1.67	3.97	0.58	150	February-September	33810-41600
Upeneus taeniopterus	70-189	128.4	260	0.66	2.53	1.44	3.97	0.64	135	February-July	
Upeneus sulphureus	80-189	126.2	215	0.76	1.73	1.58	3.31	0.52	133	July-September	
Saurida undosquamis	70-189	185.6	395	0.31	0.46	0.92	1.38	0.33	230	June-July; Oct-Dec	32630-37208
Leiognathus splendens	70-169	105.7	175	1.1	1.26	2.08	3.34	0.38	95	April-August	8960-9320
Gazza minuta	40-169	112.6	177	1.3	1.49	2.38	3.87	0.39	96	July- October	9220-12153

At Tuticorin, the optimum length at exploitation was estimated for seven species of pelagics. For the yellowfin tuna *Thunnus albacares*, the optimum length at exploitation was 68 cm.

Optimum length of exploitation for pelagics off Tuticorin

Name of species	Reference points (cm)		
	L_∞	L_{max}	L_{opt}
Scomberomorus commerson	132	135	86.0
Acanthocybium solandri	125	122	81.5
Rastrelliger kanagurta	30	29	18.0
Thunnus albacares	106	104	68.0
Katsuwonus pelamis	62	60	39.0
Euthynnus affinis	70	68	44.5
Sarda orientalis	66	64	41.9

At Mandapam, standing stock biomass, spawning stock biomass and exploitation rate of three species of demersal finfish and two species of cuttle fish were estimated based on data collected from trawl samples during the years 2007-2010. Exploitation rate ranged between 0.42 and 0.68; and the proportion of spawning stock biomass to the standing stock biomass from 16.8% to 24.2%. However, the spawning stock biomass of cuttlefish contributed 62% to the standing stock biomass.

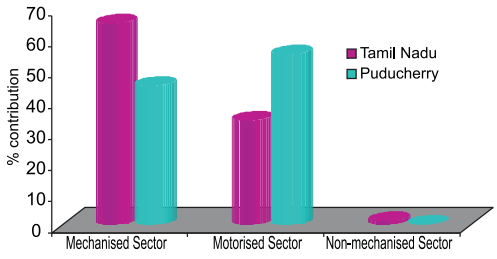
Stock parameters were estimated for three species of small pelagics off Mandapam. The exploitation rate of the Indian mackerel *Rastrelliger kanagurta* was very high at 0.93.

Stock parameters of three species of small pelagics off Mandapam

Species	L_∞ (mm)	K	Z	M	F	E
Sardinella albella	141	1.58	2.26	1.57	0.69	0.31
Sardinella gibbosa	142	1.16	3.27	1.28	1.99	0.61
Rastrelliger kanagurta	282	1.45	4.15	0.29	3.86	0.93

Potential yield and optimum fleet size estimates

Time series data on total marine fish landings and fishing effort expended in terms of hours of operation during 1990-2008 for Tamil Nadu was used to estimate the parameters of the non-equilibrium



Sector-wise landings of Tamil Nadu and Puducherry in 2010

Biomass and exploitation rate of demersal finfishes and cuttlefish off Mandapam during 2007-2010

Species	Standing stock biomass (t)	Spawning stock biomass (t)	Exploitation rate
Leiognathus jonesi	1,38,757	24,870	0.68
Upeneus sundaicus	93,426	15,718	0.62
Pennahia macrophthalmus	29,567	7,158	0.42
Sepia aculeata	312	197	-
Sepia pharaonis	574	352	-

Schaefer's surplus production model through Bayesian estimation approach using WinBUGS computer software. The estimate of potential yield for Tamil Nadu based on the analysis is 4,35,479 tonnes. The total potential yield was then distributed among the different groups based on the average catch during 2006-2008. To calculate the maximum sustainable fleet size for different fleets to harvest to the potential yield level, catch and effort of different fleets during 2006-2007 was considered and the fleets were grouped into three groups based on the percentage of demersals, large pelagics and small pelagics in the catch during this period. The total potential yield was then distributed among the fleets based on the average catch during 2006-2008 and the catch per unit and catch per hour were calculated for different fleets. For the final calculation of fleet size, data on average number of trips and hours of operation per trip was used. The recommended number of trawlers (both multiday and single day) is 4,333, against the existing fleet size of 5300. Likewise, optimum fleet size of gillnetters fitted with outboard motors is 12,689 units as against the present size of 22,478 units.

Andhra Pradesh

Length range, mean size and sex ratio of major finfish and shellfish species of Andhra Pradesh

Species	Total length (mm)	Mean (mm)	Sex ratio
Sardinella longiceps	95-219	150.9	1.15
Sardinella gibbosa	45-184	97	1.14
Sardinella fimbriata	55-184	126.5	1.5
Rastrelliger kanagurta	160-264	209.8	1.04
Rastrelliger faughnii	185-249	222.4	1.56
Thunnus albacares	280-919	549.2	1.86
Trichiurus lepturus	200-2019	1010	1.2
Nemipterus japonicus	105-285	164	1:0.5
Saurida undosquamis	120-342	213	1:2.9
Upeneus vittatus	84-236	140	1:1.2
Pennahia macrophthalmus	99-289	184	1:1.1
Metapenaeus monoceros male	81-190	128.33	1:1.74
Metapenaeus monoceros female	86-200	143.68	
Metapenaeus dobsoni male	51-120	82.16	1:0.58
Metapenaeus dobsoni female	61-115	93.92	
Portunus sanguinolentus male	86-175	121.61	1:0.48
Portunus sanguinolentus female	71-155	116.89	
Sepia aculeata	70-280	124.3	1.5
Sepia pharaonis	70-300	169	1.5
Loligo duvauceli	50-160	78.9	1.2

General trend in fishery

The total marine fish production during 2010 was 2.53 lakh t which decreased by 0.5% from that of 2009. Pelagics accounted for 1.39 lakh t forming 55% of the total landings. An estimated 0.74 lakh t of demersal fishes were landed forming 29.1% of the total marine landings. Crustaceans contributed about 0.33 lakh t, forming 13.4% of the total landings. The landing of cephalopods was 0.04 lakh t forming 1.5% of the total landings.

The dominant pelagic groups landed were clupeids (0.76 lakh t, 54.5%), mackerels (0.17 lakh t, 12.5%), carangids (0.14 lakh t, 10.2%), ribbonfishes (0.11 lakh t, 8.2%), tunas (0.085 lakh t, 6%) and seerfishes (0.07 lakh t, 5%).

The major groups that contributed to demersal landings were sciaenids (0.13 lakh t and 17.2%), silverbellies (0.08 lakh t and 11.3%), goat fish (0.07 lakh t and 9.3%), black pomfrets (0.065 lakh t and 9.1%) and catfishes (0.06 lakh t and 8.3%).

The major groups that contributed to crustacean resources were penaeid prawns (0.24 lakh t, 9.73%), non-penaeid prawns (0.02 lakh t, 0.8%), crabs (0.072 lakh t, 2.8%), lobsters and stomatopods (0.007 t, 0.3%).

The mechanized, motorized and the non-mechanized sectors contributed 48.3%, 37.8% and 13.9%, respectively.

Trawls were the major gear contributing 48.3%, followed by seines (20.4%), gillnets (14.8%), hooks and lines (2.4%) and other miscellaneous gears (14.1%). However, this is in sharp contrast to 2009, wherein the share of gillnets was 28% while that of seines was 14.5%.

Pelagic resources

Among clupeids the major contributors were *Stolephorus* contributing 0.18 lakh t, oil sardine 0.15 lakh t and lesser sardines 0.26 lakh t. Trawl catch of sardines was composed chiefly of lesser sardines (43.1%),

rainbow sardines (33.4%) and oil sardine (23.5%). The seine catch was dominated by oil sardine (60.3%) and lesser sardines (39.7%).

Carangids landed were contributed by horse mackerel (15.8%), scads (30.5%), leatherjackets (8.5%) and other carangids (45%). Among carangids, *Selar crumenophthalmus* (43.8%) and *Megalaspis cordyla* (39.8%) dominated the gill net catches while *Decapterus russelli* (41.8%) dominated the trawl landings. Mackerel formed 46% of gillnet catch of which 99% was contributed by *Rastrelliger kanagurta*. Seerfish catch was dominated by *Scomberomorus commerson* (70%) and *Scomberomorus guttatus* (30%).

More than one third of the hooks and lines catches was contributed by tunas alone. Among tuna, the dominant species landed were *Euthynnus affinis* (47.5%), followed by *Thunnus albacares* (38.9%), *Katsuwonus pelamis* (7.1%) and *Auxis thazard* (6.5%). The landings of billfishes and barracudas for the year were 0.01 lakh t and 0.02 lakh t, respectively.

Carangid landings

Demersal resources

The sciaenids landing at Visakhapatnam by mechanized trawlers consisted of *Otolithes ruber* (22.8%), *Protonibea diacanthus* (24.2%), *Pennahia macarophthalmus* (12.3%), *Nibea maculata* (10.2%), *Johnius carutta* (7.9%), *Kathala axillaris* (7.8%), *Johnius belangerii* (4.7%), *Johnieops vogleri* (3.7%), *Nibea soldado* (3.0%), *Atrobucca nibe* (2.7%), *Johnieops macrorhynus* (0.8%), *Johnius dussumieri* (0.7%) and *Johnieops sina* (0.02%).

The species of goatfish landed at Visakhapatnam by mechanized trawls were *Upeneus vittatus* (47.1%), *U. sulphureus* (24.6%), *U. moluccensis* (27.3%), *Parupeneus heptacanthus* (0.8%) and *U. tragula* (0.2%). The major species of threadfin breams landed at Visakhapatnam by mechanized trawls were *Nemipterus japonicus* (52.9%), *N. mesoprion* (20.9%), *N. delagoae* (11.2%), *N. tolu* (9.9%) and *N. luteus* (5.2%).

An estimated 0.5 lakh t of elasmobranchs were landed of which 28.1% were sharks, 1.5% skates and 70.4% rays. The major species of sharks landed were *Iago omanensis*, *Sphyrna lewini* and *Carcharhinus limbatus*. The species of rays landed were *Gymnura poecilura*, *Dasyatis kuhlii* and *Himantura jenkinsii.*

Shark landings at Visakhapatnam

Crustacean resources

The estimated penaeid prawn catch was 24,629 t contributed mainly by mechanised trawlers (80.5%) with a catch rate of 7.75 kg/h, followed by motorised seines with c/e of 160.2 kg/unit, motorised gill nets (4.16%) with 2.1 kg/unit, and non-motorised gillnets (3.3%) with 1.34 kg/unit. 23 species of penaeid prawns was seen in catches of small mechanised trawlers dominated by *M. monoceros* (23.32 %), followed by *M. dobsoni* (13.8 %), *S. crassicornis* (10.56 %), *S. melantho* (8.51%),*T. curvirostris* (7.54%) , *M. barbata* (7.2 %) and *P. stylifera* (6.43%).

The catch landed by sona boats constituted of 16 genera/ species of penaeid prawns, dominated by *M. monoceros* (30.8%), followed by *M. dobsoni* (16.3%), *Solenocera* spp. (14.6 %) and *Metapenaeiopsis* spp. (13.1%). The estimated crab landing was 7,277 t mainly by mechanised trawlers (70.3%) with 2.0 kg/h, followed by motorised

gillnets (19.6%) with 2.94 kg/unit and non-motorised gillnets (8.6%) with 1.02 kg/unit. The crab catch by trawlers was constituted of *P. sanguinolentus* (79%), *P. pelagicus* (13%) and *Charybdis cruciata* (8%).

Molluscan resources

Cuttlefish landings was 0.3 lakh t (77.3%) and squids 0.1 lakh t (22.6%). Among cuttlefish, *Sepia pharaonis* formed 46.7 %, followed by *Sepia aculeata* (39.8%) and *Sepiella inermis* (8%). Among squids, *Loligo duvauceli* was the only species landed. Maximum landings of cephalopods occurred during June - September.

Crab landings at Visakhapatnam Fisheries Harbour

The catch rate of cephalopods in mechanized trawls was 1.77 kg/h, which was higher compared to the catch rate of 0.62 kg/h in 2009. The CPUE for cuttlefish was also higher at 1.37 kg/h as against 0.44 kg/h in 2009. The CPUE for squids was however lower at 0.4 kg/h compared to 0.8 kg/h in the previous year. Juveniles formed 14.9 % of the total landings of *Sepia pharaonis,* 50.4 % of the total landings of *Sepia aculeata* and 44.6 % of the total landings of *Loligo duvauceli*.

The total bivalve production from the Bhimli Estuary was 113.6 t. The average catch per unit effort was 47.2 kg/unit. Three species of clams and one oyster (*Crassostrea madrasensis*) species were exploited from this estuary. The total bivalve catch declined by 52 % as compared to previous year mainly due to inclement weather, with frequent cyclones and thunderstorms.

Exploitation levels

Apart from lesser sardines, mackerel, ribbonfishes and cuttlefishes, all other resources caught by trawlers are exploited above optimum.

Squid (*Loligo duvauceli*) landings at Visakhapatnam

Growth and mortality parameters of major finfish and shellfish resources exploited by trawlers of Andhra Pradesh

Species	L_∞ (cm)	K	Z	M	F	E
Sardinella longiceps	21.84	1.1	5.39	2.04	3.35	0.62
Sardinella gibbosa	19.11	1.2	2.61	2.24	0.37	0.14
Rastrelliger kanagurta	27.51	0.65	2.91	1.36	1.55	0.53
Rastrelliger faughnii	25.94	0.96	4.5	1.78	2.72	0.60
Trichiurus lepturus	95.55	0.23	0.88	0.49	0.39	0.45
Nemipterus japonicus	30.45	0.48	1.66	0.59	1.07	0.65
Saurida undosquamis	35.5	0.27	1.64	0.39	1.25	0.76
Upeneus vittatus	22.5	0.30	1.17	0.47	0.70	0.60
Pennahia macrophthalmus	34.9	0.28	1.91	0.40	1.51	0.79
Metapenaeus monoceros (male)	19	2.2	10.08	3.27	6.81	0.67
Metapenaeus monoceros (female)	22.4	1.78	8.26	2.72	5.54	0.67
Metapenaeus dobsoni (male)	11.9	1.4	7.16	2.78	4.38	0.61
Metapenaeus dobsoni (female)	12.5	1.75	8.10	3.17	4.93	0.60
Portunus sanguinolentus (male)	23	1.4	7.78	2.31	5.47	0.70
Portunus sanguinolentus (female)	22	1.3	8.0	2.23	5.77	0.72
Sepia aculeata	24.5	0.88	2.96	1.77	1.19	0.40
Sepia pharaonis	23.9	0.1	0.58	0.43	0.15	0.26
Loligo duvauceli	17.6	0.3	0.78	0.22	0.56	0.72

Changes in fishing pattern for yellowfin tunas

From late 2008 onwards, there has been a change in mode of tuna exploitation at Pudimadaka and Kakinada. Earlier, the fishermen left for fishing in early hours by sail boats and returned only by night with low catch. Moreover there were obstacles in the preservation and the marketing of the fish caught. Now a days out board engines are being used when wind is not favourable. Their perception of tuna fishing changed with the advent of oil drilling by Reliance Pvt. Ltd. at Kakinada in which the drilling people used huge lights and observed congregation of yellowfin tunas in the surface waters, attracted by lights. These have resulted in fishermen going for night hunting of yellowfin tunas and have recorded good increase in both catch and catch rates. They generally leave the shore by evening and reach the fishing ground by midnight. As soon as they get sufficient catch they start returning and land their catch in the morning hours.

Yellowfin tuna landings at Visakhapatnam

Stock assessment of major finfish and shellfish resources exploited by trawlers of Andhra Pradesh

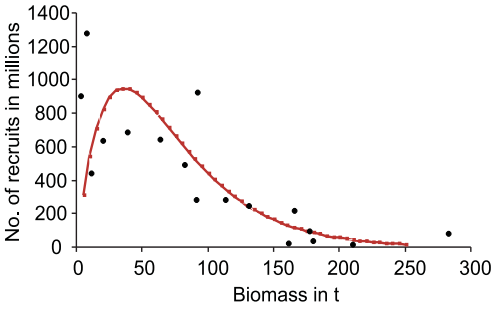
	Standing stock biomass (t)	Spawning stock biomass (t)	MSY (t)	Annual yield (t)
Sardinella longiceps	2662	492	1325	1647
Rastrelliger kanagurta	17660	5738	8349	8894
Trichiurus lepturus	35974	23923	10526	9330
Metapenaeus monoceros (male)	388	350	1764	978
Metapenaeus monoceros (female)	2423	2084	8606	2879
Metapenaeus dobsoni (male)	635	581	2079	895
Metapenaeus dobsoni (female)	1458	1167	4726	2203
Portunus sanguinolentus (male)	193	193	750	734
Portunus sanguinolentus (female)	405	360	1440	1405
Sepia aculeata	1901	609	901	725
Sepia pharaonis	7471	5669	1644	850
Loligo duvauceli	962	668	260	374

Recruitment Dynamics of Penaeid Prawns

Past data collected during 1997-2006 were subjected to analysis on calendar year basis for reproductive biology, egg production, number of recruits and relationships between egg production and recruitment of *P. stylifera* and *P. merguiensis* at Mumbai, *P. stylifera, M. dobsoni* and *M. monoceros* at Mangalore, *P. stylifera* and *M. dobsoni* at Cochin, *P. indicus*, *P. stylifera* and *M. dobsoni* at Calicut, *M. dobsoni* and *P. maxillopedo* at Chennai and *M. monoceros* at Visakhapatanam.

The relationships between month-wise recruits and egg production (spawning stock) were related with a time lag of 5 months for *P. stylifera* at Mumbai and 6 months in case of *M. dobsoni* at Mangalore, 4 months at Kochi, 4-6 months at Calicut.

At Mumbai, *P. stylifera* exhibited two peaks of egg production and recruitment giving two discrete cohorts. Egg production in March-May (pre-monsoon) gave recruitment in November-December (Cohort I) while the same in October-December (post-monsoon) gave recruitment



S-R relationship of *P. stylifera* at Mumbai

in March-April (Cohort II). The monthly estimated number of recruits and the spawning stock biomass of *P. stylifera* revealed a dome shaped Ricker's relationships with parameters: a = 11.184 b = 0.0279 (r^2 = 0.84).

At Mangalore, the average number of eggs per spawner ranged from 48,380 to 64,224 and only 0.05% of the eggs reached recruitment; the relationship between egg production and the number of recruits 6 months later, showed poor relationship (r^2 =0.021). However, egg production and the recruitment of *M. dobsoni* in relation to rainfall (pre and post monsoon) gave fairly good relation ((r^2 =0.55). The Ricker model gave better fit with parameters a = 620.8, b = 0.37 (r^2 = 0.86).

At Calicut, the average biomass of females was 15.24 t and that of spawning (54%) females 6.71 t, which gave production of 9.66 $x10^{10}$ eggs, but the survival of eggs to recruitment was 0.039%. Although primary peak of spawning was in February, recruits could not be estimated 4-5 months later as the fishing operations were closed in monsoon. The secondary peak of spawning females observed in certain years in August did not give clear relation between either spawner biomass or the egg production to the recruitment. Monsoon closure of the trawl fisheries therefore beneficial to the young recruit.

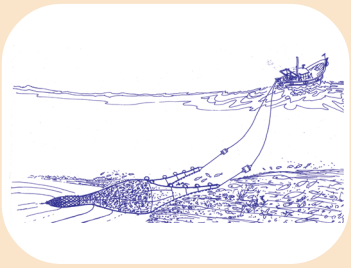
At Cochin (Sakthikulangara, Neendakara and Cochin Fisheries Harbour), the maximum spawning stock biomass and the recruits were recorded in May and June and minimum in October and March. Since both stock biomass and the number of recruits were highest in the same period they are related to intensity of landings and therefore, further detailed analysis of egg production and recruitment is required.

At Chennai, peaks of spawning biomass were noticed in July-August (primary) and January-March (secondary) but the recruitment 5 months later gave an apparent Ricker's dome shaped SR curve (r^2 = 0.43).

At Visakhapatam, although standing stock biomass of spawning females ranged between 0.01 t to 33.6 t and the recruitment 4 months, later gave Ricker's relationship showing density dependence.

Stock parameters of important species of penaeid prawns for SR relationships at different regions

Centres	Mumbai	Kochi	Mangalore	Calicut	Chennai	Vizag
Species	***P. stylifera***	***P. stylifera***	***M. dobsoni***	***M. dobsoni***	***M. dobsoni***	***M. monoceros***
Abundance	Dec & Sep	Aug	Jan-Mar	Jan & Nov-Dec	Nov-Feb	Dec-Mar
Spawners (nos. x 10^6)	219.3	N.A.	4.5-14.5	N.A.	N.A.	N.A.
Spawning stock (t)	1185 t	0.54-3787		11.43	3.6-416.6	0.03-45.66
Size at maturity (mm)	61.3 & 78.1	70	64 & 71	77.5	69	115
Peak spawning months	Apr & Dec	Aug	Feb-May & Nov.	Feb & August	Feb & Nov	Feb-Apr
Fecundity size relationship	$0.0000695L^{4.342}$	N.A.	$0.192*L^{2.847}$	$5.58*10^{-8}*L^{6.074}$	$0.4245*L^{2.66}$	F=-507+4.96L
Egg-production (nos. x 10^6)	210,000	N.A.	40.9-246 million	$9.6*10^{10}$	N.A.	N.A.
Peaks of egg production	Oct-Dec & May,	N.A.	Nov-Dec & May-June	Primary: Jan Secondary: Mar	N.A.	Feb-Apr
No. of recruits (million)	Cohort I: 383 Cohort II: 568	0.0012-2.7	N.A.	39.4	0.109-934	N.A.
Recruitment peaks	May & Aug-Sep.	Aug	May-June & Nov-Dec	N.A.	N.A.	Aug-Oct
Suitable SR model	Ricker	N.A.	Ricker	Ricker	Ricker	Ricker
Environmental relations	Rainfall	N.A.	Rainfall	N.A.	N.A.	N.A.



Fisheries Impact Assessment

Landing of bycatch

The landing of Low Value Bycatch (LVB) and discards from trawl fisheries was monitored at Veraval, Mumbai, Karwar, Mangalore, Calicut, Cochin, Tuticorin, Mandapam, Chennai and Visakhapatnam. An estimated 3.83 lakh t of bycatch valued at Rs. 192 crores was landed which form 27.8% of the total trawl catch, an increase of 24% over the previous year (3.09 t).

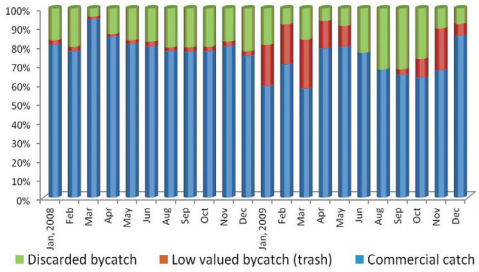
Landing of LVB at Mangalore

An estimated 25,067 t of LVB valued at Rs. 25 crores was landed by multiday trawlers (MDF) at Mangalore Fisheries Harbour. The prices of bycatch vary at different places depending upon the constituents and quality of the bycatch. The landing increased from 15.3% of total landing (14,837 t) to 25.4% in 2010 (25,678 t). The high demand for trash fish has been the major reason for increased landing. In single day trawlers, 40% of the catch was landed as trash, which was dominated by stomatopods. Landing of low value bycatch showed an increase of 16.7% at Calicut (11,694 t) and nearly 27.4% at Visakhapatnam (19,385 t). In Chennai, low value bycatch forms 15% (4,765 t) of the total trawl landing of which fishes formed 71 %. In Versova, Mumbai an estimated 2,294 t of LVB (39% of total catch) was landed. Maximum bycatch was landed during April (45%) and the lowest during September. The highest landing was at Veraval (38,507 t), which formed 25.5% of the total trawl catch and has an estimated value of Rs.15.4 crores. The value realized for bycatch at Calicut was Rs. 5.8 crores. The bycatch and discards together form 13% of the total catch (27,448 t) at Sakthikulangara-Neendakara Landing Centre.

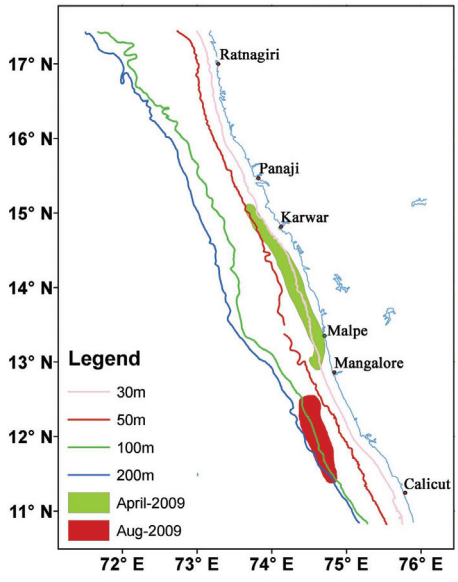
Landing of LVB at Mangalore

Estimate of trash fishes and discards from multiday fishing trawlers (MDF) operating from Mangalore Fisheries Harbour during January - December, 2010

	MDF Total	Discard (t)	Landed bycatch (t)	Discard (%)	Landed bycatch (t)
January	8060	359	2434	4.5	30.2
February	9136	456	3260	5.0	35.7
March	10123	569	3441	5.6	34.0
April	4994	244	2176	4.9	43.6
May	7490	1100	2952	14.7	39.4
June	449	169	0	37.5	0.0
August	1058	612	146	57.9	13.8
September	6369	2916	2981	45.8	46.8
October	16652	3112	2562	18.7	15.4
November	13400	1196	2444	8.9	18.2
December	20921	1044	267	9.0	12.8
Total	**98654**	**11776**	**25063**	**11.9**	**25.4**



Percentage of LVB and discards in commercial catches



Sampling areas of Karnataka

Discarded bycatch

Multiday trawlers discard the LVB during earlier part of their fishing cruise. An estimated 11,777 t was discarded by MDF at Mangalore which form 12% of total trawl catch. Maximum discards by MDF was observed during September and October. *Sardinella longiceps* is the major species in trash (24%) followed by *Lagocephalus* sp. (16%) and *Saurida* spp. (16%). Discards formed nearly 10% of the MDF catch at Calicut (3347 t). However, at Visakhapatnam, discards constituted 40,089 t, which is phenomenal in volume. While discards generally are coming down, the landed low value bycatch shows tremendous increase. At Mangalore, analysis of *insitu* discard samples of 257 trawling days showed 198 species of marine organisms whereas in Calicut, 162 species of fishes and shellfishes were found in the discarded portion of the catch. In Chennai, 84 species were identified in the bycatch, the maximum occurrence of which was noticed in October and November months.

Juvenile fishery

At Mangalore, highest percentage of juvenile fishes by weight in bycatch was of *Nemipterus* spp. (4,023 t) which results in an annual revenue loss of Rs.16.5 crores. The economic loss due to discards of juvenile fishes by trawlers at Calicut is an estimated Rs.6.6 crores.

In 'Thallumadi' fishery at Tuticorin, the average monthly catch per unit effort of prawns varied from 12-25 kg. In *P. semisulcatus* and *F. indicus*, the two commercially important species, the female prawns landed were all in immature stage. *Penaeus semisulcatus* dominated (92%) of the total catch. The size of prawns varied from 31 to 170 mm in total length.

An estimated 82 t of prawns were landed by mini trawlers, of which *P. stylifera* and *M. dobsoni* together constituted 98% of the total catch. 63% of females of *P. stylifera* were in immature stage.

Percentage of juveniles in trawl landings at Mangalore

Group	Estimated total catch (t)	Juveniles in total catch (t)	Percentage
Epinephelus diacanthus	1566	1550	99.0
Priacanthus hamrur	675	149	22.0
Scomberomorus commerson	310	307	99.0
Saurida sp.	4902	2451	50.0
Trichiurus lepturus	2164	173	8.0
Nemipterus sp.	9811	4023	41.0
Cynoglossus macrostomus	662	53	8.0
Decapterus russelli	1954	567	29.0
Lactarius lactarius	495	40	8.0
Megalaspis cordyla	625	138	22.0

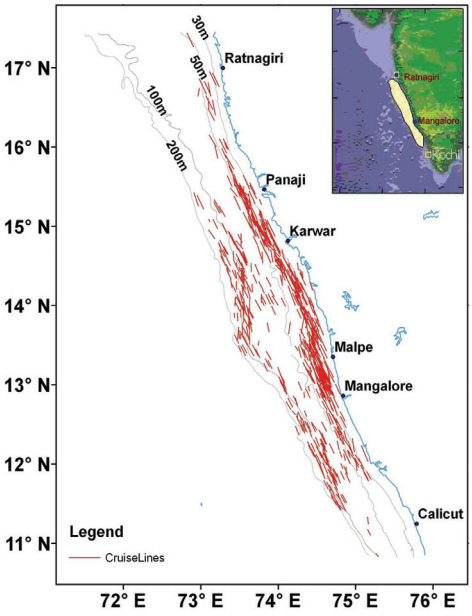
Spatio-temporal analysis of time series data on bycatch and discards in Karnataka

A participatory fishery resource assessment and management programme was initiated at Mangalore. The sea truth data on fish resources collected from a multiday fishing trawler was analysed using GIS and Visual basic softwares.

Low Value Bycatch (LVB) and discards data collected from a multiday trawler from September 2007 to April 2010 (618 days of fishing)

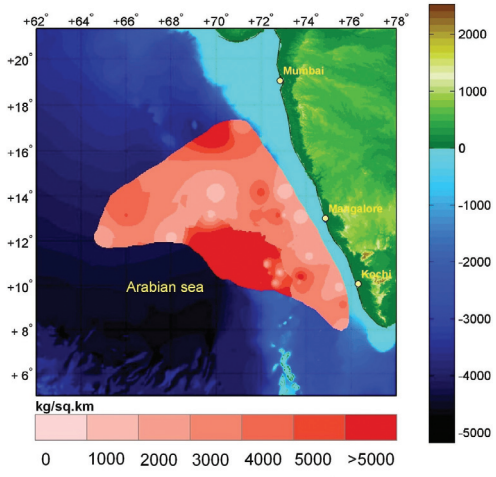
operated along the North Kerala-Karnataka-Goa-South Maharashtra coast and landed at Mangalore were analysed. Samples of discards from each haul brought to the shore were analysed. Complete information on the crew, date, hauling latitude and longitude, depth of fishing, net type and mesh total catch (kg), total discards (kg) and number of haul/day provided by the boat were analysed for spatio-temporal distribution of fishing resources using two soft wares ArcGIS and Visual Basic 6. The percentage of discards was highest during the monsoon and post monsoon months. The contribution of fishes used for edible purposes, landed as bycatch and discarded was classified. Fishes for consumption constituted only 60% and wide fluctuation in quantity of discards or bycatch landed was evident. While quantity of discards has been showing a declining trend, the landed bycatch volume has progressively increased, which require intervention to reduce damage to fish stocks. Increase in bycatch landing by multiday trawlers was mainly due to higher demand from feed manufacturing industry. The bycatch landed by single day trawlers are mostly used for human consumption.

The collection of data on a participatory mode will help in incorporating bycatch and discard component of the fishery in resource assessment studies. The information on fishing grounds and resource mapping on a spatiotemporal platform using GIS will ultimately pave way for participatory management of the fishery resource, leading to least damage to the resource and improvement in economic efficiency of fishing. The juvenile abundance of each species in space and time is available and fishermen could be advised to keep away from such fishing grounds so that the quantum of juvenile fishes caught could be considerably reduced.

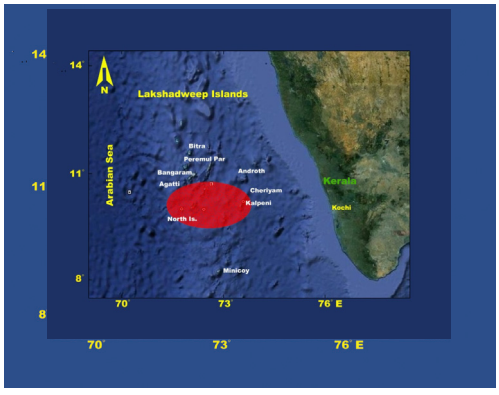


Hauling tracks of a multiday fishing trawler

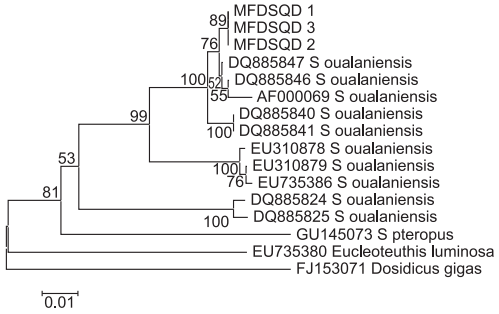
Oceanic Resources



Oceanic squid abundance maps in GIS format



Spawning ground of oceanic squids



Phylogenetic tree of *S. oualaniensis* constructed using Neighbour-joining method

Oceanic squids

Fifteen exploratory surveys and jigging cruises were undertaken in a fishing trawler (MV *Titanic*, 20 m LOA) modified for commercial squid jigging operations during 2010-11 in the Arabian Sea in depths ranging from 100 to 4,000 m. Four squid jigging machines were operated simultaneously from 1900 h to 0600 h during the surveys. The jigging cruises covered the oceanic waters from 8° N to 17° N latitudes and 64° E to 76° E longitudes along the eastern and central Arabian Sea. The oceanographic conditions of the areas surveyed were monitored by detailed analysis of salinity, temperature, dissolved oxygen, chlorophyll, rhodamine and plankton levels. Current directions and ROV observations were also recorded. Based on this a composite abundance map was prepared in GIS format. The area between the islands of Kalpeni and Agatti showed the maximum abundance in excess of 5 tonnes/km^2. Areas west off Ratnagiri also showed high abundance.

Spawning grounds of oceanic squids

Surveys were undertaken to identify spawning grounds of purple back oceanic squid *Sthenoteuthis oualaniensis* in Arabian Sea. Juveniles of oceanic squids were collected in Lakshadweep waters between 10^0 00 N 71^0 59' E and 10^0 14' N 73^0 44' E during October (between Agatti and Kalpeni islands). Dense aggregations (~1,30,000 numbers/ km^2) of oceanic squid juveniles with dorsal mantle lengths ranging from 3 to 30 mm size were observed in the surface layers during night (from 7 PM to 12 AM and 3 AM to 5 AM). In December 2010, these oceanic squids had moved in a northwesterly direction and had grown to nearly 80 mm DML indicating extremely fast growth. This preliminary observation indicates that the area around the Lakshadweep Islands is a major spawning ground for oceanic squids probably because of higher productivity as compared to the central Arabian Sea basin which is the normal foraging area for adults.

Molecular genetics of *Sthenoteuthis oualaniensis*

The COI gene sequence analysis showed that all the three samples 1, 2 and 3 were genetically the same as the pairwise genetic distance values observed between them was 0.0. Phylogenetic analysis, BLAST searches and the BOLD system analysis for species identification showed up to 99% similarity with *Sthenoteuthis oualaniensis*.

Product development

Three frozen IQF products and 2 dried products were developed. The IQF products were fillets, strips and tentacles. A product brand identity was also developed.

Oceanic squid fishing techniques

Squid fishing techniques using automatic jigging machines, gillnetting, hand jigging, purse seining, dip and lift netting were developed. The techno-economic feasibility of the different techniques is being evaluated.

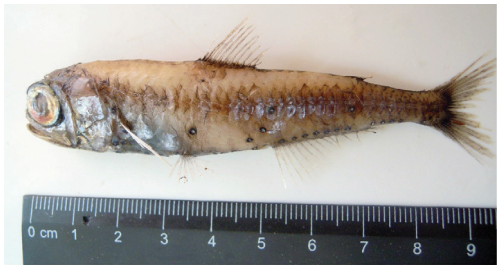
Oceanic squids caught by gillnet

Myctophids

Myctophid fishery by deep sea shrimp trawlers were monitored and biology of major species were studied. Information on the catch and catch composition was collected through enquiry.

Catch of myctophids by week-long fishing trips ranged between 840 and 1,680 kg/trip. For want of market demand the entire catch used to be thrown overboard. Myctophid was caught more in night hauls.

Five species- *Diaphus watasei*, *Diaphus garmani*, *Benthosema fibulatum*, *Myctophum obtusirostre* of the family Myctophidae and *Neoscopelus microchir* of the family Neoscopelidae, supported the myctophid fishery. *D. watasei* was most abundant and available almost round the period.



Myctophum obtusirostre

Diversity of myctophids was more during January – March. *D. watasei* in the catch was supported by 6.2 to 13 cm size population. *D. garmani* by 6-7 cm, *B fibulatum* 3-10 cm, *M. obtusirostre* 6-10 cm and *N. microchir* 4-32 cm population, In *D. watasei* catch, females were dominant with sex ratio- male: female is 1: 2.13. Individuals with matured and spent ovary were available throughout the year indicating year-round spawning. Euphausids is the most important food item, followed by copepods, prawns and small squids.

The proximate composition of *D. watasei* shows 15.62% protein, 11.71% fat and 0.28% soluble carbohydrate. Monounsaturated fatty acids (MUFA), which formed 36.7% is almost comparable with other food fishes.

Myctophids formed the main food item of eight of the 15 co-existing fishes. DNA barcodes were generated for *N. microchir, D. watasei* and *B. fibulatum*.

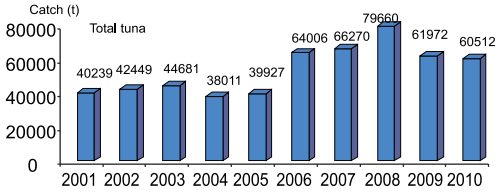
Unsorted catch by a deepsea trawler at Neendakara Fishing Harbour, Kollam

Huge quantities of protein-rich resources are discarded into the sea every year. Concerted effort may be put to make use of this resource effectively for the society, like development of value added product for human consumption or as a protein source in the diet of domestic animals and fishes. Such developments will lead to the selective exploitation of this resource and development of associated industries.

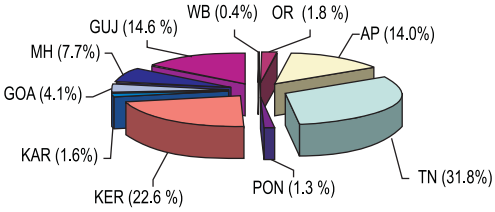
Tunas

Landings

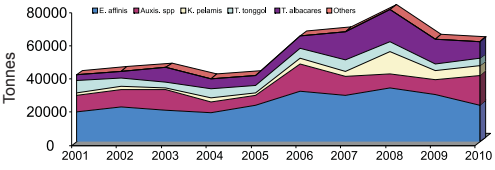
Total tuna landings in 2010 was 60,512 t along the mainland coast and 7,883 t at Lakshadweep, registering a marginal decline by 2.4 and 4.6%, respectively as compared to 2009. They represented 1.97% of the total marine fish production of the mainland and 81.3% of Lakshadweep during 2010. Tuna from Indian EEZ was exploited by long lines, gillnets, pole and line, trawl, hand lines, troll line, purse seines and ring seines. Fishery for oceanic tunas restricted to outer edge of continental shelf and oceanic waters close to continental shelf.



Tuna production along the mainland coast during 2001-2010



Percentage contribution of maritime states to national tuna production in 2010



Variation in the yield and composition of different species of tunas in the catch during 2001-2010 along the mainland coast of India

Skipjack tuna landings by hooks and line at Kochi

Annual growth rate of tuna catch along the mainland ranged from 3.5- 60.3% during 2005-2008 recording the peak production of 79,660 tonnes in 2008. However, during 2009 production trend reversed by registering 22.2% decline over 2008 with a production of 63,187 t. Production further declined to 60,512 t in 2010 registering 4.3 % decline.

Along Lakshadweep, annual growth rate of tuna production was 4.7% and 4.5% respectively in 2008 and 2009; whereas it declined in 2010 by 5.3%.

Southeast coast representing Tamil Nadu, Puduchery and Andhra Pradesh contributed 47.1% of the tuna catch. Among maritime states, Tamil Nadu and Kerala topped in tuna production by contributing 31.8% and 22.6 % of the total catch followed by Gujarat (14.6 %) and Andhra Pradesh (14.0%).

Species-wise tuna landing during 2008-10

Fishery was supported by eight species along the mainland coast; six at commercial level and two as incidental catch. Coastal tunas dominated the catch by 66.1 % represented by *Euthynnus affinis* (36.5 %), *Auxis thazard* (22.2 %) and *A. rochei* (7.4 %). Neritic tunas formed 7.4 %, represented by *Thunnus tonggol* (7.4 %) and *Sarda orientalis* (<0.1%). Oceanic tunas formed 26.5 % represented by *T. albacares* (16.9 %), *Katsuwonus pelamis* (9.5 %), and the rest by *Gymnosarda unicolor* (<0.1 %).

Region-wise contribution of different species of tuna during 2010

Species	Northeast	Southeast	Southwest	Northwest	Lakshadweep
E. affinis	3.3	42.9	29.8	23.2	0.8
A. thazard	2.2	57.4	33.8	5.7	0.9
A .rochei	2.2	58.0	34.1	5.7	0.0
K. pelamis	1.5	25.6	6.8	15.1	51.0
T. tonggol	0.7	0.0	3.3	96.0	0.0
T. albacares	0.0	47.2	28.8	10.7	13.3
S. orientalis	0.0	30.8	41.0	28.2	0.0
G. unicolor	0.0	0.0	87.0	0.0	13.0
Total	**1.9**	**41.7**	**25.1**	**19.8**	**11.5**

Along Lakshadweep coast, fishery was supported by six species. The catch is dominated by oceanic tunas (96.1%) represented by *K. pelamis* (76%), *T. albacares* (19.9 %) and *Gymnosarda unicolor* (<0.1%). Catch of coastal tunas was dominated by *E. affinis* (2.3%) and *A. thazard* (1.6 %) and small quantities of *A. rochei*

Distribution and biology

Coastal and neritic tunas

Fishery registered a decline in 2009, but improved marginally in 2010. The declining trend in production of little tuna/kawa kawa continued in 2010 as in 2009, but reversed in the case of all other species

Little tuna/Kawa kawa *Euthynnus affinis*

Production after reaching a peak of 32,406 t in 2008, showed a declining trend along the mainland to 28,563 t in 2009 and to 22,097 t (22.6%) in 2010. Declining trend (- 26%) was observed in Lakshadweep also.

Species mature and spawn round the year with peaks during July-August and November-January. Fecundity was estimated as 3,08/g body weight. L_c is higher than size at maturity (L_m) but lower than the optimum size (L_{opt}) for exploitation. Stock assessement suggests measure to reduce the effort for sustaining the yield in the present grounds and expansion of fishing to less exploited areas for enhanced production.

Estimates of some important reference points of tuna species

Species	L_r	L_{ma}	L_{mat}	L_{opt}	L_c
E. affinis	18	78.0	37.7	40.1	39.7*
A. thazard	18	51.0	27.5	28.8	28.4*
A. rochei	16	39.0	23.6	24.5	24.2*
T. tonggol	32	92	53	57.4	52.3*
S. orientalis	32	58	34	36	37.4**
T. albacares	23	182	53	61.1	39.7*
K. pelamis	12	89	34	45	28.4*
G. unicolor			62	67.7	

Outboard longline/handline boats at Tuticorin for tuna fishing

Frigate tuna *Auxis thazard*

Production after continuous decline during 2007-2009, registered an increase (+ 96%) to an all time high of 13,912 tonnes in 2010. Production improved in all states, except from Andhra Pradesh, Kerala and Lakshadweep, where it declined. They mature and spawn round the year with peak during September-January. Fecundity was estimated as 8,08/g body weight. L_c is above the size at maturity and optimum size (L_{opt}) for exploitation. Stock assessment indicate scope for improving the production from the present grounds.

Outboard gillnetters at Pudhiyappa, Calicut for tuna fishing

Bullet tuna *Auxis rochei*

Production increased continuously during 2008-2010 due to improved contribution by gillnets and hooks and line. More than 86% of the catch was contributed together by Tamil Nadu and Kerala. They mature and spawn round the year with peak during July-September. Fecundity was estimated as 1,203/g body weight. Size L_c is higher than the size at maturity but lower than the optimum size (L_{opt}). Stock assessment indicate scope for improving their production.

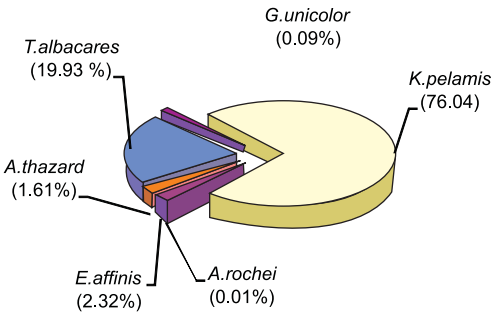
Longtail tuna *Thunnus tonggol*

Major abundance and fishery (96%) is from northwest coast comprising Maharashtra and Gujarat. Production declined in 2009 and then marginally improved in 2010.Their catch improved in all states except from Kerala and Gujarat. Species mature and spawn round the year with peak during September-January. Fecundity was estimated as 133/g body weight. L_c is below the size at maturity and L_{opt}, which necessitate measures to improve the size at first capture of the exploited fishes.

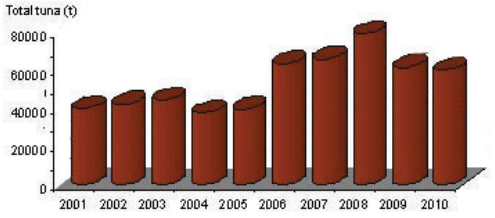
Oriental bonito *Sarda orientalis*

After a sudden spurt in production to 1,115 t along the mainland coast in 2009, catch declined sharply by 96.5% to 39 t in 2010. They mature and spawn round the year with peak during May-September. Fecundity was estimated as 4,04,000/kg body weight. Size at capture is higher than the size at maturity and optimum size (L_{opt}) for exploitation.

Young ones (14-22 cm FL) of bonito (*Sarda orientalis*) landed by trawlers at Tuticorin



Percentage contribution of different species to total tuna catch of Lakshadweep.



Tuna production along the Lakshadweep coast during 2006-2010

Yellowfin tuna landed by longliners at Kochi

Oceanic tunas

Skipjack tuna *Katsuwonus pelamis*

Production remained as of 2009 with a marginal improvement along the mainland. Except from Tamil Nadu and Gujarat, production from other regions declined sharply. In Lakshadweep, production declined by 11%.

Fishery was supported by fishes of 12-72 cm size along Lakshadweep coast and by 40-83 cm along the mainland coast. Species mature and spawn round the year with peak during September-December. Fecundity was estimated as 301 eggs/g body weight. Size at capture is very low compared to size at maturity and optimum size (L_{opt}) for exploitation.This situation neessitate regulation of fishery to improve the size at capture and to improve the stock.

Yellowfin tuna *Thunnus albacares*

This species was exploited by hooks and line (52.5 %), gillnets (34.2%), pole and line (2 %), and purse/ring seines (9.5%). Andhra Pradesh and Tamil Nadu contribute 59.3% of the catch followed by Kerala (30%) and Lakshadweep (13%). Production declined by 25.7% along the mainland. Except marginal improvement in the catch in Andhra Pradesh and Puduchery, production declined sharply in all other areas. On the other hand production improved from Lakshadweep by 30%.

Fishery was supported by 27-181 cm size fishes along mainland and 22-185 cm along the Lakshadweep. *T. albacares* mature and spawn round the year with peak during August-January. Fecundity was estimated as 436 eggs/g body weight. Size at capture is very low compared to size at maturity and optimum size (L_{opt}) for exploitation which will adversely affect the stock in the long run.

Stock assessment of yellowfin tuna indicates tremendous scope for increasing the yield. MSY of yellowfin tuna from the Indian EEZ including the Lakshadweep excluding Andaman is estimated as 103, 368 t $\pm$ 7,264 t.

Dogtooth tuna *Gymnosarda unicolor*

This species contributed mainly to the fishery along the Lakshadweep and south-west cost. Catch registered 81% decline along the mainland, and marginal improvement along the Lakshadweep coast. Fishery was supported by fishes of 43-158 cm. The species mature and spawn round the year with peak during August –January. Fecundity was estimated as 315/g body weight.

Value chain in Lakshadweep tuna fishery

The landings of yellowfin tuna registered increase from 957 t in 2007 to 1571 t (64% increase) in 2010, due to target fishing by islanders.

Tuna fishing at Agatti and Androth islands by modified Pablo boats

Five pablo boats converted and modified for tuna longlining at Agatti and Androth. Fishing operations conducted at Androth by two converted boats caught 0.4 t of yellowfin tuna and 0.1 t of bycatch comprising sharks and sailfish during 67 fishing days. In Agatti total landing

constituting yellowfin tuna and bycatch was 1.5 t of which yellowfin tuna catch varied from 14-63%.

Tuna fishing operations by 62' tuna longliners

Two 62' tuna longliners conducted 11 fishing cruises of 8-13 days duration each. Each boat covered 96 fishing stations and caught 1 t yellowfin tuna ranging in length from 53 to 112 cm fork length. The modal size class varied from 73 to 76 cm in September and 65-68 cm in October. However, modal size class was 33-40 cm during November and December.

Biological studies

The food and feeding habits of yellowfin tuna ranging in length from 30 to 112 cm fork length were studied. The swimming crab *Charybdis smithi* is the dominant food item (52%) followed by *Auxis thazard* (26%) and digested matter (15%). Otoliths from yellowfin tuna and skipjack tuna were collected for ageing study.

Production of value added products

Production technologies for 'tuna roll', a ready to serve product and 'liquid smoked masmin' a value added product were developed. Treatment with liquid smoke could completely eliminate the toxic benzopyrene in masmin and the technology has been applied for production of masmin flakes, a consumer friendly product. The 'improved masmin' will enhance the quality of traditional masmin which has high benzopyrene levels. Pig feed prepared from tuna waste (silage) is undergoing feed trials at Kerala Agriculture University, Thrissur. The silofeed with improved nutritional profile is undergoing field testing for seabass at the marine cage farm at Karwar.

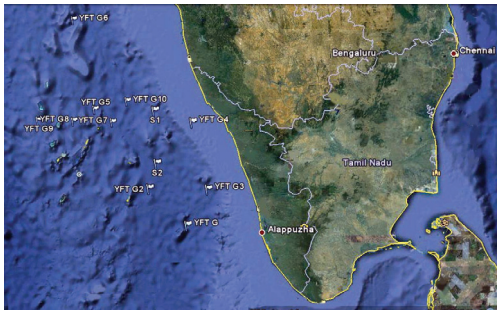
Management options

Deep sea vessels with combination gears involving long lines/ handline/gillnets and troll line has to be introduced and fishing effort must be extended to the outer edge areas and also to other less exploited areas of EEZ for improving production.

Continuous monitoring of the resource has to be done to understand the production trend and to propose conservation measures of the resource.

Possibilities of cage farming of undersized yellowfin tunas caught at Lakshadweep may be investigated for better management and enhanced production.

Masmin flakes



Yellowfin tuna fishing grounds in Lakshadweep Sea

Marine Mammals

Sousa chinensis in Cochin backwaters

Common dolphin *Delphinus capensis* off Kollam

Sousa chinensis sighted in the coastal waters of Karwar

Two opportunistic visual surveys were carried out onboard FORV *Sagar Sampada* to assess marine mammal diversity and their distribution in oceanic waters of western and eastern parts of the Indian seas and southern part of Sri Lankan waters (Indian Ocean). A total of 244 hours of survey effort was made in 35 days to cover about 495 nautical miles during the period. A total of 10 sightings of one species of baleen whale and six species of delphinids were recorded, which comprised of about 1,074 individuals. *Stenella longirostris* (spinner dolphin) was the most frequently sighted species showing a wide distribution.

Sighting of killer whale *Orcinus orca* was recorded for the first time in Andaman waters. *Balaenoptera musculus* (blue whale) was recorded on one occasion. High frequency of occurrence of baleen whale (*Balaenoptera* sp.) was observed along the southern Sri Lankan waters.

Five boat based short surveys, each for a duration of two hours were undertaken aboard an outboard-engine boat (overall length: 7m) in Cochin backwaters. The Indo-Pacific humpbacked dolphin *Sousa chinensis* was sighted on all occasions. No other species was sighted in Cochin backwaters. Photo samples of external body marks and scars, which are unique to each individual were taken and compared with existing image database to distinguish individuals in different groups for estimation of the population size. The survey indicated occurrence of two groups, each comprising of 2 to 10 individuals of adults and subadults. Observation on behaviour showed that Indo-Pacific dolphins often use Cochin backwater areas especially the barmouth of Vypin and Fort Cochin, where Chinese nets are operated, for feeding during high tide. For Dolphin Watch, the high tide period in Cochin backwaters appears to be an ideal location. During every survey, in addition to population estimation, response of humpbacked dolphin to heavy vessel traffic was observed. Behavioral response of each individual to vessel movement was recorded. Most of the individuals demonstrated quick response to vessel movement by moving out of the vessel course to avoid getting collided. Heavy vessel traffic did not affect the feeding behaviour of humpbacked dolphin.

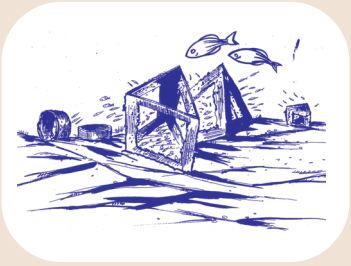
Boat-based surveys onboard a fishing vessel (OAL: 10 m) were carried out off Karwar continuously for seven days during March 2011. A total of 11 sightings of 38 individuals were observed during the survey period. The Indo-Pacific humpbacked dolphin *Sousa chinensis* was sighted on all the days. A total of 32 individuals of 9 small groups were recorded and each group consisted of 3 to 6 animals of adults and sub adults. The finless porpoise *Neophocaena phocaenoides* was sighted on two days. The population abundance in the area is being estimated.

During the survey, interaction between humpbacked dolphin and trawl and purse seine fisheries was observed regularly. During purse seine

operation, it was observed that groups consisting of 30 animals congregate in fishing area and surround purse seine net and cause disturbance to fishing by taking away fishes from the net. In order to prevent this disturbance, two types of measures are practiced by the fishermen. Some fishermen use crackers to drive away the dolphins from their fishing area. However, fishermen are cautious to avoid causing physical injury to dolphins. Some fishermen patrol the fishing area on small boat. Trawl fishing is also disturbed by the dolphins.

To assess the diversity of marine mammals in the Southern Ocean, 45-day opportunistic visual surveys for marine mammals were conducted onboard ORV *Sagar Nidhi*. Minke whale *Balaenoptera bonaerensis* (6 groups) and killer whale *Orcinus orca* (6 groups) were the two confirmed species sighted between 49° 34' S, 57° 53' E and 60° 00' S, 52° 18' E. Five species of seabirds (3 albatross and 2 petrels) were observed during the cruise.

Killer whale *Orcinus orca* in Southern Ocean



RESOURCE ENHANCEMENT

Reef fish and triple ring modules

Grouper modules being loaded into boat

Deployment of triple ring module into the sea from ERP boat

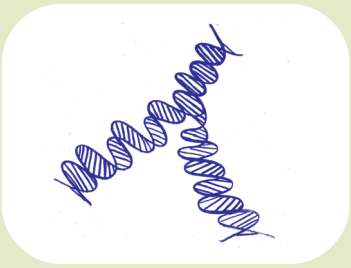
For enhancing biological resources of the coastal region, with special emphasis on increasing fish production, Tamil Nadu Fisheries Department approached Central Marine Fisheries Research Institute for deployment of artificial reef modules at four sites in the inshore waters of Tamil Nadu. The suggested sites were off Light House Kuppam near Pulicat in Thiruvallur District, Chinnaneelankarai in Kancheepuram District, Mallipattinam in Thanjavur District and Arockiapuram in Kanyakumari District. A village-level "Artificial reef fabrication, deployment and monitoring committee" was formed in the four villages. As a package of technology transfer from CMFRI to local fisherfolk community, the volunteers selected by village committee were imparted training in artificial reef fabrication and deployment through a non-government organisation 'PLANT' under the guidance of CMFRI.

Fabrication of three types of artificial reef modules i.e., ring module, reef fish module and grouper module, totalling 200 numbers were done as per the specification stipulated by CMFRI. The sea survey for site selection off the respective village was carried out by PLANT with the technical guidance of CMFRI by deploying SCUBA divers and GPS. At each location, the survey team identified sandy and rocky areas at a depth of about 8-11 metres as the suitable sites for deployment of artificial reef.

Deployment of artificial reefs was conducted at all the four places with the participation of the officials of Tamil Nadu Fisheries Department, CMFRI, NGOs along with panchayat leaders and fishermen. Artificial reef modules were deployed at the selected sites in the sea by the fishermen themselves with the use of their catamarans, fibre glass boats and mechanised boats.

At Light House Kuppam and Chinnaneelankarai, the ring modules and reef fish modules were manually carried and placed on the FRP boats and transported and deployed at the selected sites by the fishermen during April and May 2010 respectively. As the grouper modules were heavy, those structures were lifted with the help of crane from the fabrication site and placed on the boat for transportation and deployment at the selected sites off Light House Kuppam during September 2010 and off Chinna Neelankarai during November 2010. Artificial reef modules were deployed off Mallipattinam and Arokyapuram by engaging mechanized boats in May and in September 2010, respectively. The village federation at each fishing village appointed local volunteers to regulate the fishing effort and fishing methods in the artificial reef zone.

In six months, the quality and the quantity of the fish catches improved, yielding better economic returns to the fishermen. Thus the artificial reefs enhanced the fishery resources and provided an alternate fishing ground to the fishermen. The reefs became popular in the area and fishermen from nearby villages requested for the same project in their villages also.



Fish Genetics and Genomics

Biotechnological applications in mariculture and conservation

Functional genomics of bivalves

Molecular genetic characterisation of the functional genes involved in stress tolerance and disease resistance of marine bivalves and finfish, and the genes involved in pearl formation were carried out.

Molecular Identification and characterization

Identification and characterization of the functional genes belong to three categories viz. anitoxidant enzymes, stress related proteins and defense related peptidases playing vital role in the development and overall survival of the animal amidst fluctuating environment in Indian backwater oyster *Crassostrea madrasensis,* and the genes involved in pearl formation in *Pinctada fucata* were conducted.

Antioxidant enzymes genes

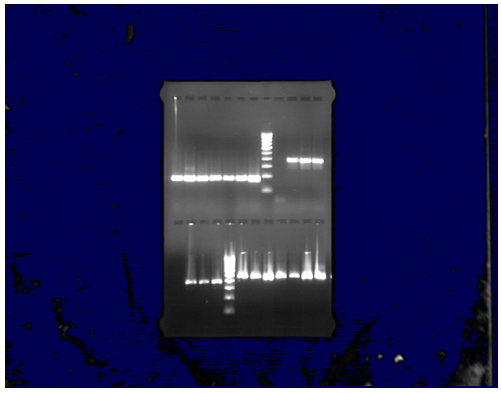
Antioxidant enzymes are protecting the cells from oxidative stress and prevent damage to cellular functions caused by reactive oxygen species (ROS).

Super oxide dismutase (SOD)

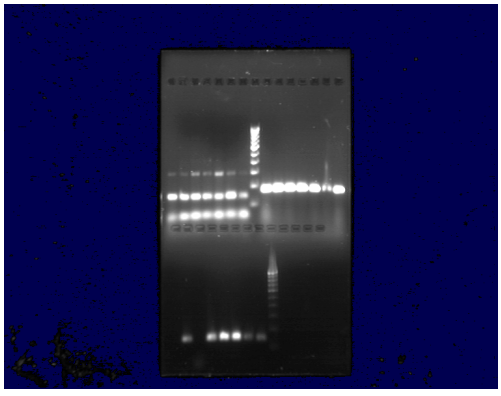
The antioxidant enzyme super oxide dismutase (SOD) which is generated inside the body to prevent oxidative damage removes superoxide radicals by the process of dismutation into oxygen and hydrogen peroxide. Since there are no reported work on the SOD gene of *C. madrasensis*, different primer pairs were custom synthesized following the DNA sequences reported in Pacific oyster *C. gigas*. Cross PCR amplification trials attempted were successful and resulted in a 464 bp SOD gene segment. The amplified PCR products were gel eluted and purified and sequenced. The sequence obtained was confirmed as the target gene on subsequent BLAST search in the NCBI Genbank database.

Catalase (CAT)

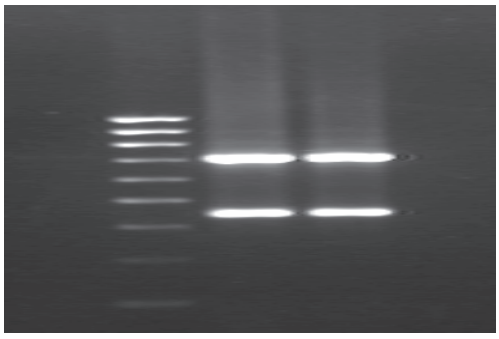
The antioxidant enzyme catalase (CAT) is an oxidoreductase which removes toxic hydrogen peroxide by breaking down two molecules of hydrogen peroxide into two molecules of water and oxygen. CAT along with other antioxidant enzymes help the oyster to survive the oxidative stress. As in the case of SOD, the cross amplification strategy was attempted using different primer pairs based on the sequences of pacific oyster. A specific primer pair resulted in the amplification of a fragment with 171 bp size which was confirmed as catalase on sequencing and BLAST search for similarity in NCBI database.



SOD, CATALASE and HSP 90 in *Crassostrea madrasensis*



PCR amplified functional genes of *Crassostrea madrasensis*



PCR amplified heat shock protein gene of *Lates calcarifer*

Stress tolerance genes

Molecular identification of heat shock protein 90 (hsp90)

Hsp 90 is one of the important members of the heat shock protein family with a major role in the synthesis, folding and prevention of denaturation of proteins, as well as signal transduction. The molecular identification and preliminary characterization of another prominent member of the HSP family viz. HSP 70, was reported last year. The effort during the year under report was to locate another important class of heat shock protein Hsp 90 in *C. madrasensis* by its PCR amplification. Appropriate primers were designed and PCR conditions were optimized for the amplification of HSP90 gene. Expression of Hsp 90 was confirmed from the PCR amplification of the partial coding sequence using cDNA templates generated from the mRNA isolated from the gills using specific sets of primers which produced an amplicon of 187bp.

Marine finfish genetics

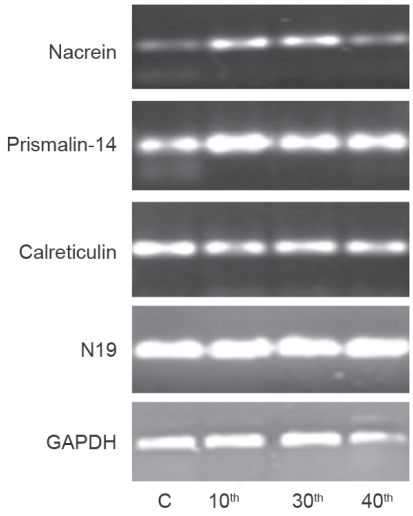
Work on the heat shock protein gene in finfish of mariculture importance *Lates calcarifer* was also initiated. Presence of hsp was confirmed through PCR amplification of the genomic DNA using specific primers.

Expression analysis of genes involved in the biomineralization of mabe pearl

Expression analysis of four genes involved in biomineralization process of pearl formation viz. nacrein, prismalin-14, calreticulin and N19 following mabe implantation was continued during the year. Semi-quantitative PCR analysis was used for this.

Semi-quantitative PCR

PCR primers were designed using Beacon designer (Bio-rad) based on the published gene sequences. Specificity of primers was ensured with NCBI primer blast webpage server (www.ncbi.nlm.nih.gov/tools/primer-blast). Housekeeping gene encoding glyceraldehydes-3-phosphate dehydrogenase (GAPDH) was selected as reference for the calculation of relative expression levels of target genes.



Agarose gel images of semi-quantitative PCR of Nacrein, Prismalin-14, Calreticulin and N19 genes carried out with cDNA samples from the mantle surrounding the mabe of implanted *P. fucata*. Glyceraldehyde-3-phosphate dehydrogenase (GAPDH) was included as a positive control; lane: 1, PCR product of non-implanted control; lane: 2, 10th day; lane: 3, 30th day; lane 4, 40th day after implantation

Semi-quantitative PCR was performed using cDNA as template, to compare the expression profiles of the four genes in the mantle tissue of implanted and control oyster at different time period.

The differential expression patterns of the four genes in the implanted oysters at different time intervals and the control were quantified based on the gel band intensity using image analysis software. In general, mRNAs of all the four genes were detected in target tissues with different levels of expression. Though the expression of these genes in the mantle surrounding the mabe showed differential expression levels, the general trend was an up-regulation between 10^{th} and 30^{th} days after implantation. Expression levels of nacrein, prismalin-14 and N19 showed a

predominant up-regulation with slight variations among the different time periods. Expression levels of nacrein and prismalin-14 were similar and reached highest expression on 10th day after implantation and then gradually decreased until 40th day. The expression of N19 showed a marked up-regulation on 30th day and then decreased by 40th day to the 10th day level. Expression level of calreticulin in the implanted oysters was lower than the controls, though the difference was only marginal.

Biological characterization of target species *viz*. pearl oyster *Pinctada fucata* and edible oyster *Crassostrea madrasensis* from different natural habitats with respect to economically important traits and molecular characterization of target species from different habitats using mitochondrial DNA markers like Cytochrome b, ATPase 6 and Control region, and microsatellite markers to document their intra-species genetic variability and to identify distinct genetic stocks if any for breeding strategy and conservation, has been taken up.

Biological characterization

Morphometric database was strengthened by collection of more animals and measurement of morphometric parameters from samples collected from Veppalodai, Punnakayal and Korampally of Tuticorin and Pulicat and Muthukad lakes of Chennai.

Molecular characterization

PCR amplification of the mitochondrial genes viz. cytochrome b, ATPase 6 and control region of *C. madrasensis* from different natural habitats were carried out using custom synthesized primers. The amplified segments were sequenced, aligned and used for estimating genetic divergence values and for constructing phylogenetic trees (Neighbor Joining 'NJ') using MEGA 4.

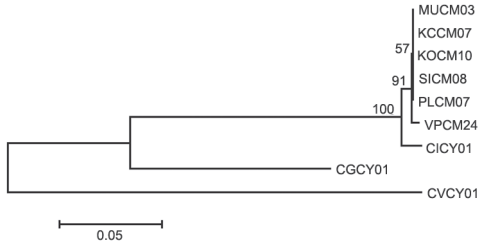
Nucleotide-sequence divergences were calculated using the Kimura-two parameter (K2P) model. The sequence data of *Crassostrea virginica* (Accession No. NC_007175.2), *Crassostrea iredalei* (Accession No. FJ841967.1), *Crassostrea gigas* (Accession No. NC_001276.1) for ATPase, Cyt B and Control region, from NCBI was used as out groups. The analysis generated phylogenetic trees and many clades were established with strong tree-support values.

Cytochrome B

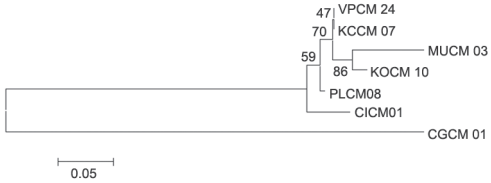
DNA of *C. madrasensis* samples from Chennai, Tuticorin, Kollam and Sattar Island were PCR amplified using for Cytb specific primers Cm Deg-Cyt b F & CmDeg-Cyt R. Sequence of the 650 bp product on BLAST search showed similarity to Cyt b of other *Crassostrea* species. In the NJ trees one major cluster was formed by the *C. madrasen*sis samples along with *C iridea*. These were supported by high bootstrap values (NJ 99- 100 %; MP 91-99%).

Control region

DNA of *Crassostrea madrasensis* from Chennai, Tuticorin, Kollam and Sattar Island were PCR amplified for Control region using specific primers Ct F and Ct R, and product sequenced. The sequences show a 93% similarity to *C. iredalei* on BLAST analysis. Sequencing of the



Neighbour-joining phylogram showing the relationship between Cyt b haplotypes from *Crassostrea* sp.



Neighbour-joining phylogram showing the relationship between Control haplotypes from *Crassostrea* sp.

Control region resolved ~515 nucleotide base pairs. Multiple alignments resulted in a consensus length of 231 sites including base pairs and gaps. Sequences from each location were included in the phylogenetic analysis.

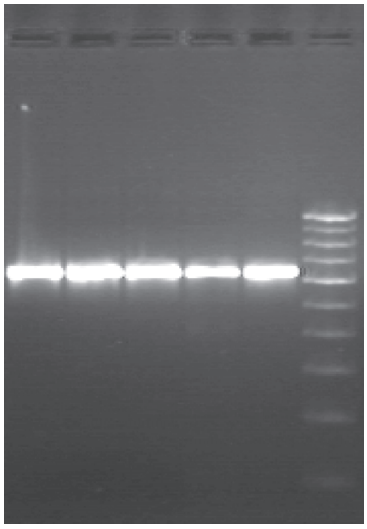
Genetic distance values of *Crassostrea* sp. using ATPase gene

	PLCM08	MUCM03	KOCM10	KCCM07	CGAT01	CVAT01	CIAT01
PLCM08	*****						
MUCM03	0.000	*****					
KOCM10	0.002	0.002	*****				
KCCM07	0.000	0.000	0.002	*****			
KCCM07	0.000	0.000	0.002	0.000	*****		
CGAT01	0.174	0.174	0.176	0.174	0.174	*****	
CVAT01	0.401	0.401	0.404	0.401	0.401	0.373	*****
CIAT01	0.012	0.012	0.014	0.012	0.012	0.179	0.399

In the NJ tree, one major cluster was formed by the *Crassostrea madrasen*sis along with *C. iridea*. The clusters were supported by high bootstrap values (NJ 99- 100 %; MP 91-99%).

ATPase 6

DNA of *Crassostrea madrasensis* from Chennai, Tuticorin, Kollam and Sattar Island were PCR amplified using specific primer for ATPase region viz. ATPIR F and ATPIR R. The resultant product of 650 bp was sequenced. The sequences showed similarity to ATP ase region of other *Crassostrea* species (98% similarity to *C. iredalei* and 78% to *Saccostrea mordax*) on BLAST analysis.



Agarose gel electrophoresis image of ATPase 6 sample

Sequencing of the ATPase 6 gene produced ~650 nucleotide base pairs. Multiple alignments resulted in a consensus length of 584 sites including base pairs and gaps. Sequences from each location were included in the phylogenetic analysis.

Development of species specific DNA markers in green mussel and edible oyster

Resource mapping and sample collection of *P. viridis* (green mussel) and *C.madrasensis* (edible oyster) were carried out along the maritime states of India.

The PCR protocol for amplifying mitochondrial CO1 gene (partial) standardized and was generated sequence database for *P. viridis* and *C. madrasensis* in GenBank (33 submissions; FJ428750 to FJ428758 and JF520789 to JF520812).

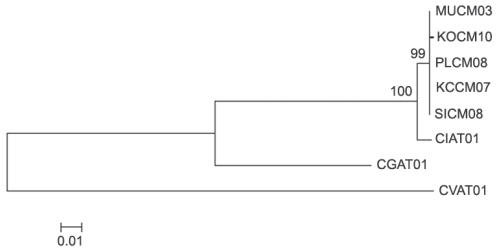
Species specific PCR primer based on the CO1gene both for *P. viridis* and *C. madrasensis* was developed and the PCR protocol for the same was standardized. Species specificity of the designed primers was proved with the specificity assay. Other bivalve species which occur in the same niche were also included in the specificity assay and it was found that the specific primers produced positive results only with the target species.

Two step nested PCR was designed for the sensitive detection of the target DNA in a pool of mixed DNA from other related species. The system was found to be effective to detect the target DNA of concentration as low as 0.1ng when occurring in a pool of DNA from other organisms

found in plankton samples. Also the system proved effective to identify a minimum of two veliger larvae from an experimental plankton biomass of 40 mg that would yield approximately 250 ng/µl DNA.

Sensitivity assay for the nested PCR showing species specific amplicons of *Crassostrea madrasensis* in DNA isolated from experimental plankton samples added with *C.madrasensis* veliger larvae at varying numbers. A minimum of two larvae could be detected (Lane 2) from the experiment. Application of the species specific nested PCR for *P. viridis* and *C. madrasensis* in natural plankton samples was verified. The system could identify the presence of target species larvae in natural plankton samples.

Population genetic studies on different populations of *P.viridis* and *C. madrasensis* collected from Kerala, Tamil Nadu, Karnataka, Andhra Pradesh and Orissa are in progress using the potential microsatellite primers identified for population studies.



Neighbour-joining phylogram showing the relationship between ATPase6 haplotypes of *Crassostrea* sp.

Development of genetically improved strains of brine shrimp *Artemia*

Survey and collection of indigenous *Artemia*

Exploratory survey was carried out in the hyper saline areas of the Indian subcontinent and native *Artemia* strains were collected, identified and preserved to establish *Artemia* reference centre.

State	Location / Strain code	Nature of Sample	Type
Gujarat	Mithapur (GMJ)	*Artemia* & Cyst	Bisexual
	Nanganvadi (GNM)	*Artemia*	Bisexual
Rajasthan	Sambhar and Didwana Lakes	Nil	
Maharashtra	Meera Road, Thane, Uran, Vassai Road	Nil	
Tamil Nadu	Kelambakam (CKF)	*Artemia* & Cyst	Bisexual
	Marakkanam (TTM)	*Artemia* & Cyst	Bisexual
	Thamaraikulam (TNM)	Cyst	Bisexual
	Tuticorin (TTJ)	*Artemia* & Cyst	Bisexual
	Vedaranyam (VDA)	*Artemia* & Cyst	Bisexual
Orissa	Ganjam, Humma, Sumadi, Suran, Model salt farm	Nil	
West Bengal	Contai/Kanthi, Digha, Sankar pur, Bengal salt	Nil	
Andhra Pradesh	Nellur, Iskapalli, Ramatheertham	Nil	

Cross breeding programme

Diallel cross breeding carried out to test the breeding efficiency and reproductive performance of the native strains with the reference *Artemia franciscana* strain (SFB) revealed the absence of reproductive barrier between the Indian and *Artemia franciscana* reference strain. Life history traits such as, first day length (FDL), third day length (TDL), sixth day length (SDL), Length of male at sexual maturity (LMS) and Length of female at sexual maturity (LFS) of the crossbred progenies were matured

Life history traits of the F1 generation *Artemia*

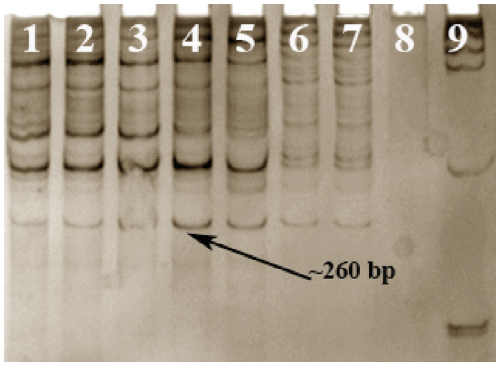
Cross								
Male	**Female**	**Nauplii[1]**	**Cyst[2]**	**FDL**	**TDL**	**SDL**	**LMS**	**LFS**
CKF	SFB	54 ± 28	87 ± 0	617.3 ± 31.50	1243 ± 244.1	3.3 ± 0.52	6.73 ± 0.59	7.86 ± 0.63
	VDA	32 ± 6	89 ± 0	597.3 ± 40.08	1108 ± 115.9	2.8 ± 0.25	6.2 ± 0.75	6.46 ± 1.12
	TTJ	75 ± 29	NA	541.3 ± 55.40	1246 ± 203.0	2.8 ± 0.65	6.86 ± 0.83	7.86 ± 0.83
	GMJ	79 ± 10	NA	596 ± 35.81	1296 ± 158.6	4.6 ± 0.60	7 ± 0.8	7.73 ± 0.45
	CKF	55 ± 43	89 ± 0	628 ± 144.3	1153 ± 146.0	3.5 ± 0.59	7.6 ± 0.63	7.26 ± 0.79
VDA	SFB	27 ± 6	61 ± 0	590 ± 79.19	1125 ± 258.0	2.93 ± 0.99	7.06 ± 1.48	9.06 ± 1.33
	CKF	88 ± 7	NA	591.3 ± 33.77	1220 ± 38.03	1.19 ± 0.26	6.8 ± 1.20	6.4 ± 0.50
	TTJ	49 ± 32	126 ± 0	664.6 ± 17.67	1383 ± 159.4	3.46 ± 0.51	7.33 ± 0.61	7.73 ± 0.88
	GMJ	46 ± 14	135 ± 0	576 ± 55.78	1266 ± 100.7	3.28 ± 0.71	6.66 ± 0.89	7.33 ± 0.61
	VDA	80 ± 67	68 ± 0	576.6 ± 79.43	1361 ± 328.8	2.6 ± 0.82	6.46 ± 1.12	7.93 ± 0.70
SFB	CKF	56 ± 25	88 ± 0	663.3 ± 30.86	1473 ± 70.37	4.06 ± 0.92	7 ± 0.65	7.2 ± 1.26
	VDA	98 ± 25	NA	557.3 ± 90.03	1328 ± 112.9	3.1 ± 0.54	6.2 ± 0.77	7.73 ± 1.38
	TTJ	61 ± 21	NA	588.6 ± 49.26	1403 ± 100.8	3.76 ± 0.56	6.13 ± 0.83	7.46 ± 0.74
	GMJ	78 ± 5	NA	552 ± 38.02	1373 ± 148.0	4.73 ± 0.67	5.93 ± 0.88	7.6 ± 0.82
	SFB	55 ± 24	90±0	560.6 ± 97.13	1424 ± 158.1	3.9 ± 0.87	5.93 ± 0.70	7.46 ± 0.83
TTJ	CKF	37 ± 9	NA	614.6 ± 71.30	1211 ± 76.68	3 ± 1.03	7 ± 1.25	7.86 ± 1.06
	VDA	23 ± 8	NA	591.3 ± 49.98	1096 ± 221.9	3.13 ± 1.09	6.66 ± 0.72	8.13 ± 1.45
	SFB	44 ± 1	NA	591.3 ± 70.08	1323 ± 109.1	4.06 ± 0.77	6.6 ± 0.63	7.93 ± 0.70
	GMJ	23 ± 8	NA	580 ± 33.38	1271 ± 146	4.03 ± 0.83	7 ± 1.19	6.93 ± 0.45
	TTJ	61	NA	552 ± 116.38	1453 ± 316	3.48 ± 1.31	6.66 ± 0.72	7.33 ± 0.97
GMJ	CKF	58 ± 25	NA	548 ± 44.43	1353 ± 69.35	2.36 ± 0.58	6.73 ± 0.45	7.06 ± 0.70
	VDA	51 ± 8	NA	506 ± 48.37	1121 ± 106.8	2.73 ± 0.59	6.6 ± 0.72	7.4 ± 0.91
	SFB	44 ± 5	NA	626 ± 19.19	1000 ± 67.48	2.8 ± 0.41	7 ± 0.65	7.4 ± 0.82
	TTJ	102 ± 4	NA	490 ± 32.07	1175 ± 227.3	2.22 ± 0.165	6.6 ± 0.50	6.2 ± 0.41
	GMJ	54 ± 8	94 ± 0	555.3 ± 85.67	1411 ± 269.4	4.2 ± 0.9	6.26 ± 0.79	7.06 ± 0.79

Average Nauplii at first hatch[1]

Average Cyst at first hatch[2]

Data with standard deviation; first day length (FDL), third day length (TDL), sixth day length (SDL), Length of male at sexual maturity (LMS) and Length of female at sexual maturity (LFS).

Where, CKF: Kelambakam, Tamil Nadu; VDA: Vedaranyam, Tamil Nadu; TTJ: Tuticorin, Tamil Nadu; GMJ: Mithapur, Gujarat; GNM: Nanganvadi, Gujarat; TNM: Tamaraikulam, Tamil Nadu; TMM: Marakanam, Tamil Nadu and SFB: *Artemia franciscana*-San Francisco Bay strain.



Profile of microsatellite loci amplified by the primers BP9-16-2 showing ~180bp products of different populations of *Perna viridis* collected from different locations

Selective breeding

Mass selection was practiced to develop small nauplii strain (SNS) following the established method with suitable modifications. Selective breeding was carried out for fifteen generations (F_1 to F_{15}). Substantial reduction in naupliar size could be achieved. Naupliar length (first day length -FDL) could be reduced from 517 microns to 439 through selective breeding. Correlated response in other life history biometric traits such as third day length (TDL), sixth day length (SDL), length of male at sexual maturity (LMSM) and Length of female at sexual maturity (LFSM) are also calculated.

Heritability

Heritability of nauplii length was estimated from the full sib analysis using the R statistical package v2.9.0 (R Development Core Team 2009).

Life history traits of the selected *Artemia* strain generation wise

Generation	FDL	TDL	SDL	LMSM	LFSM
G0	517.0 ± 59.8^{d}	1.28 ± 0.19^{a}	3.67 ± 0.89^{h}	6.72 ± 0.70^{bcde}	6.96 ± 0.56^{ab}
G1	514.6 ± 20.5^{ef}	1.29 ± 0.20^{a}	3.65 ± 0.84^{h}	6.74 ± 0.82^{bcde}	7.10 ± 1.03^{bc}
G2	504.7 ± 38.5^{df}	1.29 ± 0.21^{a}	2.63 ± 0.56^{bcde}	6.41 ± 0.62^{ab}	6.75 ± 0.83^{a}
G3	501.7 ± 20.3^{bcde}	1.05 ± 0.21^{a}	2.53 ± 0.48^{abc}	6.78 ± 0.68^{e}	7.57 ± 0.95^{e}
G4	491.0 ± 38.7^{bcd}	1.05 ± 0.17^{a}	2.58 ± 1.10^{bcd}	6.77 ± 0.49^{bcde}	7.11 ± 0.68^{bc}
G5	490.1 ± 19.4^{bcdef}	1.20 ± 0.22^{a}	3.07 ± 0.30^{fg}	6.85 ± 0.36^{de}	7.03 ± 0.64^{ab}
G6	482.5 ± 23.1^{def}	1.06 ±0 .11^{a}	2.25 ± 0.40^{ab}	6.55 ± 0.50^{abcde}	7.45 ± 0.50^{de}
G7	477.1 ± 27.1^{bcd}	1.44 ± 0.28^{b}	2.73 ± 0.44^{cdef}	6.90 ± 0.53e	7.47 ± 0.66^{cde}
G8	471.4 ± 27.1^{cdef}	1.15 ± 0.05^{a}	2.82 ± 0.24^{cdef}	6.58 ± 0.50^{abcd}	7.17 ± 0.39^{bcd}
G9	464.1 ± 30.1^{b}	1.15 ± 0.07^{a}	3.08 ± 0.82^{efg}	6.75 ± 0.72^{abcde}	7.78 ± 1.00^{ae}
G10	463.4 ± 24.8^{bde}	1.26 ± 0.06^{a}	2.39 ± 0.28^{defg}	6.60 ± 0.55^{abe}	7.51 ± 0.47^{b}
G11	459.4 ± 21.4^{cdef}	1.25 ± 0.24^{a}	3.12 ± 0.32^{g}	6.95 ± 0.21^{d}	7.54 ± 0.50^{de}
G12	454.5 ± 29.1^{bc}	1.13 ± 0.03^{a}	2.58 ± 0.34^{abc}	6.90 ± 0.29^{e}	7.64 ± 0.48e
G13	452.2 ± 25.0^{de}	1.14 ± 0.06^{a}	2.20 ± 0.24^{a}	6.74 ± 0.44^{cde}	7.17 ± 0.37^{bc}
G14	444.4 ± 31.8^{def}	1.17 ± 0.05^{a}	2.34 ± 0.23^{a}	6.94 ± 0.23^{cde}	7.05 ± 0.23^{ab}
G15	439.3 ± 27.0^{a}	1.04 ± 0.08^{a}	2.16 ± 0.23^{a}	6.37 ± 0.48^{a}	7.55 ± 0.50^{de}

The pooled heritability estimate for the 15th generation was 0.94 ± 0.27.

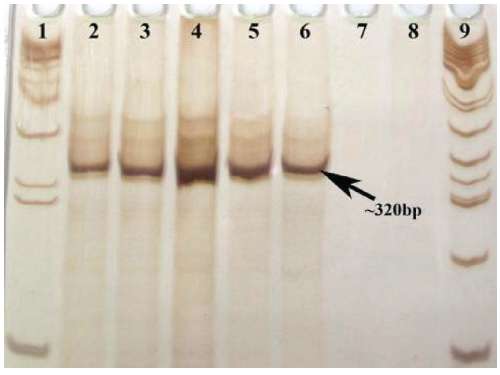
Identification and characterization of elongase gene in the brine shrimp *Artemia*

Elongase gene encoding elongase which is involved in the synthesis of long chain fatty acid in *Artemia* was carried out. Synthesis of elongase cDNA from the *Artemia* of Indian origin was carried out by reverse-transcription of RNA isolated from the *Artemia* nauplii following standard methods. PCR amplification of the elongase gene was carried out using degenerate primers which were designed based on the conserved motifs in the elongase sequence. The PCR products were sequenced and searched for homology in the nucleotide database of NCBI Genbank using tblastn programme. The sequence showed 72% identity to the PUFA elongase of *P. humanus corporis and* 71% identity to *A. aegypti*, *A.albopictus* and other insects, as both crustaceans and insects comes under the phylum Arthropoda. Aminoacid sequence was deduced. BLAST search of protein database at NCBI revealed high homology (95%) with long chain fatty acid elongases of several insects. Partial characterization of the fatty acid elongase gene of *Artemia* involved in the production of long chain fatty acids have been achieved.

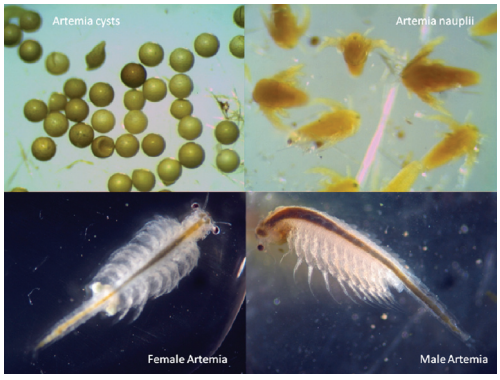
Bioprospecting of genes and allele mining for abiotic stress tolerance

Sample collection

Water samples were collected from water bodies spanning 21 different locations along the west and east coasts of India for screening of microalgae. Marine, brackish and hypersaline waters from sea, lagoons, lakes, salt pans, aquaculture farms and hot springs were collected by filtering through 50µm and 20µm mesh filters.



Profile of microsatellite loci amplified by the primers UCDCG172 showing ~320bp products of different populations of *Crassostrea madrasensis* collected from different locations.



Different life stages of the native *Artemia*

Indian bisexual *Artemia*- Riding pairs

Isolation of algae

Standard procedures were followed for isolating microalgal strains, which included serial dilution, agar plating and micropipette method. Pure isolates were cultured in sea water (with dilution or concentrating with NaCl wherever needed) enriched with f/2 [Guillard (1975)] and Walne's [Walne (1970)] media for all microalgae. Media composition was modified according to the requirement for some cultures. All together 146 isolates are maintained under laboratory conditions.

Identification of microalgae

Phenotypic identification

Isolated strains were identified morphologically under a microscope based on the color of culture, cell size, shape, cell inclusions, flagellar organization, movement patterns of the organism etc. Microscopic images were digitally captured using *Leica DMLS – DFC295* microscope and stored for further reference.

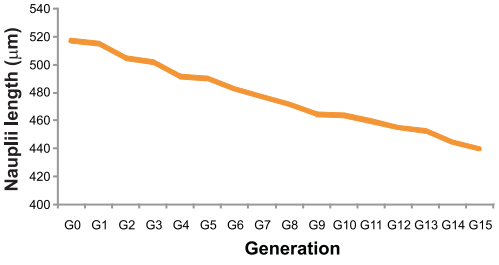
Genotypic identification

The species identities of morphologically identified strains were confirmed using molecular taxonomy. Molecular identification was carried out by sequencing partial regions of selected loci (18S rDNA, COI, 16S rDNA and *rbc*L) and comparing it with database (NCBI) using BLAST algorithm. Genomic DNA was extracted from 125 microalgae isolates using modified Lysozyme and Proteinase k method of Wu *et al.,* (2000). Gene specific PCR were carried out using specific primers and amplified products were sequenced for further analysis. Sixty seven (67) isolates were identified using molecular taxonomic methods.

Number of isolates sequenced at different loci for molecular identification

Name of locus	18S rDNA	16S rDNA	COI	ITS
No. of isolates sequenced*	65	04	27	07

*Same isolate sequenced for more than one locus



Nauplii length of the selected *Artemia* in different generations

Gene mining in marine algae

Four different genes conferring tolerance to high salinity and nutrition depletion conditions were partially/completely characterized by PCR using different combinations of primers. Another five more genes were partially characterized by constructing cDNA library.

Hydroxy methyl butenyl diphosphate reductase (HDR) gene from *Dunaliella* sp.

HDR is an enzyme playing a key role in the regulation of isoprenoid biosynthesis and is required for tolerance to high salinity and nutritional depletion conditions. The full length (complete CDS from start codon to stop codon) HDR gene (~1960 bp) was amplified from cDNA using the primers HDR3Fw (5'TGATGTTGTCCAACAGCTTC3')and HDR4Rev (5'CCGGGTTGTGGATGATTTC GTTGGT 3'). This amplified product has been cloned into pJET1.2 cloning vector. The full gene sequence information has been generated from both ends using the vector specific forward and reverse primers.

Details of genes characterized and sequence information generated

Gene	Host species	PCR / SSH	Sequence information generated	Remarks
4-Hydroxy-3-methylbut-2-enyl diphosphate reductase (HDR) gene	*Dunaliella* sp.	~2000 bp (Complete CDS – PCR amplified)	1960 bp sequenced (complete CDS)	Complete CDS characterized and cloned
Desaturase-D (des D) gene	*Arthrospira platensis*	~850 bp (partial – PCR amplified)	780 bp sequenced (partial)	
Phytoene synthase gene	*Dunaliella* sp.	~450 bp (partial – PCR amplified)	415 bp sequenced (partial)	
Sodium Dependant Phosphate Transporter (SDPT) gene	*Dunaliella* sp.	~450 bp (partial – PCR amplified)	—	
Fructose-1,6-bisphosphatase (FBP)	*Dunaliella* sp.	SSH clone	370 bp (partial)	Further analysis is being done
Glyceraldehyde 3-phosphate dehydrogenase (GAPDH)	*Dunaliella* sp.	SSH clone	249 bp (partial)	
2-oxoglutarate-dependent dioxygenase (AOP)	*Dunaliella* sp.	SSH clone	250 bp (partial)	
Aspartic protease	*Dunaliella* sp.	SSH clone	254 bp (partial)	
60S Ribosomal protein	*Dunaliella* sp.	SSH clone	200 bp (partial)	

Desaturase-D gene from *Spirulina* sp.

The newly designed primer pair APL301F (5' TGGAGTTTCCGCCGTCGGTT 3') and APL1138R (5' GCTCGATCGCTTTTGTTTCCGGG 3') gave a good amplification of partial desaturase-D gene product of about 850bp in *Arthospira platensis* (S-016). The resultant PCR product has been sequenced generating 780 bp sequence information which was taken for further analysis.

Phytoene synthase gene is a regulatory gene playing a major role in carotenoid biosynthesis by catalyzing Phytoene formation under stressed conditions. A 450 bp product of Phytoene synthase gene has been amplified from cDNA of *Dunaliella* sp. using the primers PSY1(5'GTTCTCGAGTAT GCCAAGACTTTCTACC3') and PSY2 (5'CATATCGATCAGGATGTTGGTCAGCTGG 3') and sequenced. Further analysis is being done with the amplified product.

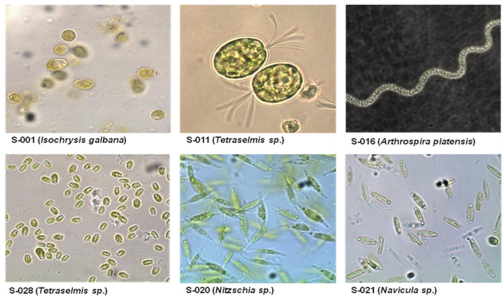
Phytoene synthase gene from *Dunaliella* sp.

Sodium dependant phosphate transporter (SDPT) gene from *Dunaliella* sp.

Sodium Dependant Phosphate Transporter (SDPT) gene was amplified from cDNA of *Dunaliella* sp. using the primer pair YDvSPT1FP1 (5' ATTGAATTCACCATGG CGGACGTGGACAGCTTCAGC 3') and YDvSPT1RP1 (5' TCCCTCGAGTTAAGGCATGGTCT GCTCAGA 3') which gave an amplified product of 450 bp. Further analysis is being done with the amplified product.

Salinity tolerance experiment

Salinity tolerance experiment was carried out using 13 different isolates of *Dunaliella* sp. (S-86, S-89, S-96, S-109, S-110, S-111, S-118, S-121, S-122 and S-133) in order to find out the tolerance level of each isolate under salinity stress. All the 13 isolates were cultured under same condition using same culture media, other than NaCl concentration. Each



Morphological features of different microalgae isolates

Gene/DNA sequence submissions

Sl.No.	Gene / DNA sequence definition	GenBank Accession Number
1	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520789
2	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520793
3	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520794
4	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520795
5	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520796
6	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520797
7	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520798
8	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520799
9	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520800
10	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520801
11	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520802
12	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520803
13	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520804
14	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520805
15	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520806
16	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520807
17	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520789
18	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520812
19	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520790
20	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520791
21	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520792
22	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520808
23	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520809
24	*Perna viridis* mitochondrial cytochrome c oxidase subunit1, partial coding sequence	JF520810
25	*Crassostrea madrasensis* voucher CMFRI-MBTD-VCM24 cytochrome b (cytb) gene, partial cds; mitochondria.	HM 043821
26	*Penaeus monodon* voucher CMFRI-MBTD-KPM10 hemocyanin mRNA, partial cds.	HM 595417

Highlights of Significant Achievements

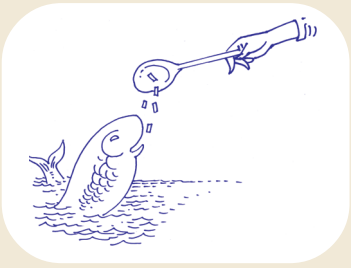
Collection, isolation, purification and maintenance of 144 pure isolates of marine microalgae representing different habitats of Indian coast.

Phenotypic and genotypic identification of more than 100 isolates of marine microalgae.

Gene mining (partial and complete characterization) of 9 important genes conferring tolerance to the survivability of marine microalgae under abiotic stressful conditions.

Complete characterization of HDR gene conferring tolerance to high salinity and nutrition depletion conditions.

isolate was allowed to grow at four different salinity conditions such as 0.5 M, 1.5 M, 2.5 M and 3.5 M NaCl. The growth rate was measured by counting the cell density at different time interval after inoculation at day 1, day 6, day 10, day 20 and day 28. Graphs were plotted based on cell density values at different time interval at different NaCl concentration for each isolate separately for comparison. The carotenoid content of these isolates at different salinity were also estimated.



Fish Nutrition

Functional feeds for aquariculture

A brood stock nutritional trial with sword tails (*Xiphophorus helleri*) is carried out at present. The formulation contains 500 g kg^{-1} protein and ajowain oil (*Trachyspermum copticum*) g kg^{-1} known as *ayamodakam* in Malayalam. It contains thymol (active ingredient) which is a part of a naturally occurring class of compounds known as biocides, with strong antimicrobial attributes when used alone or with other biocides.

A custom made feed with 50% protein and phytoextracts (Garcinia sodium salt, ajowain oil and garlic oil) was provided to ornamental fish farmers and Kerala Aquaventures International Ltd. (KAVIL) and a significant increase in fecundity and larval survival was observed.

Feeds for cage farming

Formulated slow sinking nursery feeds developed and used for nursery rearing provided to artisanal cage fish farms at Kottapuram under Kottapuram Integrated Development Society (KIDS) showed good acceptability in sea bass fingerlings.

A formulated slow sinking feed with around 41% protein, 16% fat and 2% fibre has been developed and tested for finfish nursery rearing. The feed is presently under evaluation using *Lates calcarifer* fingerlings.

Ornamental fish feed

Cadalmin™ *Varna,* the marine ornamental fish feed developed and field tested is presently under the process of commercialization. Till then the product is sold only through ATIC of CMFRI and through the exhibition stalls.

A broodstock feed incorporating selected phytoextracts was formulated and successfully tested for aquariculture. This functional feed is under refinement.

Lobster nutrition

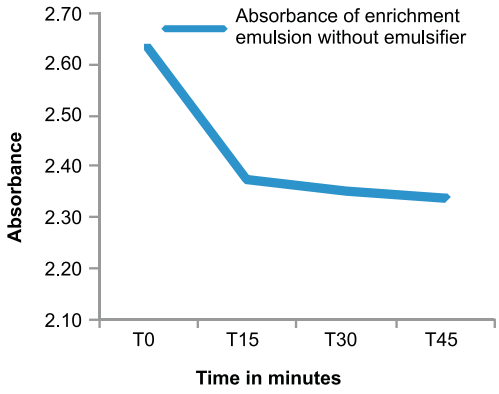
A formulated feed was made and evaluated in the spiny lobster *Panulirus homarus* maintained in captivity. Using this feed, an evaluation was conducted to test the acceptance and its effect on the body composition.

Individually measured lobsters were grown in cement tanks of 10 m^2 area with flow-through water system and reduced light intensity (12h L: 12h D schedule). Water temperature range between 26 °C and 28 °C was maintained. Salinity was in the range of 30-36 ppt and pH, 7.8-8.0. Stocking density was 5m^2. Cannibalism at moulting was negligible.

Percent ingredient composition of lobster feed formulation evaluated

Ingredients	Parts 100^{-1}
Sardine fermented	65
Wheat gluten	10
Soya Flour	10
Soya Lecithin	2
Cod Liver oil	6
Bentonite	2
Earth Mix	2
Shell Powder	2
Vitamin Mix	1

The experiment revealed the acceptance of the formulated feed by the lobsters with high survival and without any adverse effects on their body composition. Further refinement of the formulation and its evaluation with reference to growth parameters and cost effectiveness will be taken up.



Emulsion stability of the PUFA concentrate (without addition of emulsifier T20)

Fatty acid profile of marine microalgal species belonging to Prymnesiophytes and Eustigmatophytes

Four microalgal species, viz., *Nannochloropsis oculata*, *Dicrateria inornata*, *Pavlova viridis*, and *Isochrysis galbana* were used as polyunsaturated fatty acid (PUFA) enrichment diet, and were analyzed for fatty acids.

Among the four microalgae, the SFA content in *D. inornata* and *I. galbana* were found to be significantly low (23.81 and 28.95%, respectively) ($p<0.05$) than recorded in *P. viridis* and *N. oculata* (35.16 and 38.64 %, respectively).

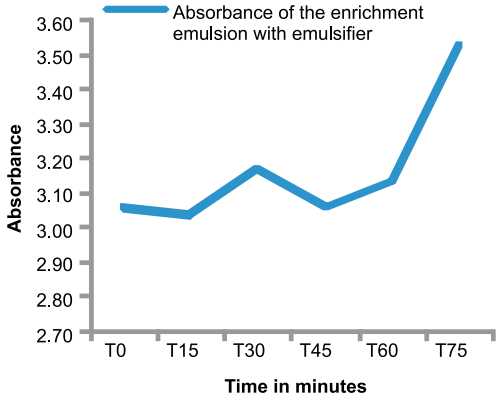
The highest PUFA was observed in the microalgae, *I. galbana* (43.31%) followed by *D. inornata* (39.01%), *P. viridis* (23.41%) and *N. oculata* (19.81%). *I. galbana* showed highest docosahexaenoic acid (DHA, 9.75%) resulting in a higher DHA: EPA ratio (3.75) than recorded in other microalgae (0.07-0.19).

Among the microalgae, *N. oculata* recorded significantly high arachidonic acid (AA, 2.15%) and eicosapentaenoic acid (EPA, 9.69%) ($p<0.05$).

The present study revealed the importance of *Isochrysis galbana* as a candidate microalga for its nutritional excellence.

Percentage fatty acid composition of microalgae

Saturated Fatty Acids	*P. viridis*	*D. inornata*	*N. oculata*	*I. galbana*
ΣSFA	35.16	23.81	38.64	28.95
ΣMUFA	38.71	33.07	38.01	24.54
20:5n3	9.54	6.82	9.69	2.60
22:6n3	1.81	1.26	0.64	9.75
ΣPUFA	23.41	39.01	19.81	43.31
Σn3/n6	2.11	3.31	1.32	3.60
ΣPUFA/ΣSFA	0.67	1.64	0.51	1.50



Emulsion stability of the PUFA concentrate (with addition of emulsifier T20)

Use of emulsifiers to contain the stability of enriched PUFA emulsion

An experiment was conducted to understand the effect of emulsifiers to stabilize the n-3 PUFA concentrate prepared. The emulsifier used was T20 which was able to contain the stability of the preparation for an extended time period.

The stability of the PUFA concentrate (as such without T20) decreased after 15 min, whereas the same appended with T20 was able to maintain the stability for an extended period of time due to Brownian movement.

Development and evaluation of larval feed enrichment emulsion

Evaluation of the live feed enrichment emulsion (LFEE-CMFRI) developed by CMFRI was carried out at Vizhinjam Research Centre and Mandapam Regional Centre.

The results of the larval nutritional trial conducted at Vizhinjam RC in clown fish (*Amphiprion ocellaris*) indicates that rotifers enriched with *I. galbana* which is a DHA rich algae is the best live feed with a survival percentage of 75. The trial was of 9 days duration.

In cobia (*Rachycentron canadum*) at Mandapam, from 3rd day post hatch (dph) to 10 dph and fed with rotifers enriched with *Nanochloropsis oculata,* the survival rate was 27%. With DHA-Selco (from INVE Belgium) the survival was 60% and with the LFEE-CMFRI, the survival rate was 46%.

Larviculture trials in cobia from 9-18 dph with four treatment regimes using *Artemia* nauplii as the live food organism showed the following results:

Growth and survival of cobia 9-18 dph

	Unenriched *Artemia*	**DHA-Selco**	**LFEE-CMFRI**	**Algamac**
Replications	**Larval survival out of 50 individuals**			
1	13	38	20	15
2	15	32	18	21
3	11	35	23	21
% survival	26	70	40	38
Average initial length mm	6.46	6.9	6.9	6.9
Average final length mm	17.2	19.4	17.6	17.3
Average initial weight mg	0.62	0.65	0.66	0.65
Average final weight mg	2.30	3.16	2.54	2.31

Among the different larval enrichment products tested, DHA-Selco from INVE recorded the highest survival percentage followed by LFEE-CMFRI under development. The experiments were conducted in 100 L tanks with uniform management.

Experiments at Vizhinjam Research Centre of CMFRI are now focused on to optimize the concentration of the oil to be used below 1 ml l^{-1} preventing (1) the formation of the oil film while feeding enriched rotifers and (2) the optimum number of rotifers required/ml to match the growth and survival observed in control.

Ornamental fish feed

In order to develop and test feeds for freshwater ornamentals, eight feeds have been evaluated and formulated with ascending nutrient densities in terms of protein with almost similar energy levels with some nutrient and non-nutrient additives.

Feed preparation

Locally available feed material was used for formulating the feeds. The feed material contributing macronutrients sourced were analyzed for the proximate constituents.

Feeds were formulated in an Excel spreadsheet and the percentage ingredient composition, proximate analysis and cost analysis were carried out. All the feeds were extruded in a laboratory model twin-screw extruder (BTPL, Kolkata, India) and assessed for their bulk density and hydrostability. The extruded feeds were crumbled and sieved through 0.75 mm crumbles which was found to be the suitable particle size the fish was able to consume at the time of acclimatization.

Hydrostability (% dry matter remaining after elapse of 0 - 4 h) and bulk density g l^{-1} and crumble buoyancy

TIME IN HOURS	0	1	2	3	4	Bulk density g L^{-1}	Pellet buoyancy
P59	100	77.54	77.10	76.44	75.64	612.31	Sinking
P53	100	76.25	76.07	74.76	73.98	583.24	Slow sinking
P47	100	84.43	83.67	83.44	82.85	580.70	Slow sinking
P40	100	85.66	85.05	84.83	83.30	516.57	Neutral
P33	100	90.26	90.00	89.40	88.37	483.83	Neutral
P26	100	92.52	91.36	90.87	88.83	486.77	Neutral
P19	100	94.02	93.10	92.70	91.55	467.67	Floating
P16	100	95.59	94.97	93.16	91.04	413.26	Floating

Fish and feeding

The koi fry were obtained from a local aquarium fish dealer (www.aquariummareena.com). The fish were acclimatized in 250 L tanks with *in-situ* biological filters with continuous aeration. Groups of 10 fry of average weight 158 mg were weighed and stocked in 24 glass aquaria of 50 l capacity containing dechlorinated freshwater in a recirculation system. Ninety percent of the water was renewed with fresh water fortnightly. The water quality parameters (APHA 1985) were assessed fortnightly.

For 84 days the fish were fed to satiation at 10.00 am, 1.00 pm and 4.30 pm. In order to arrive at the consumption rates, known quantity of feed was offered during the third and fourth weeks (14 days); feed and faecal residues were collected and quantified. At the end of the experiment, individual body weight of all the fish as well as the biomass per tank was recorded. Dried and stored samples were used for proximate analysis and frozen samples were used for estimating amino acids and fatty acids.

Growth performance and feed utilization pattern were assessed by recording final body weight, determining net body weight gain, specific growth rate (SGR), feed intake, feed conversion ratio (FCR) and protein efficiency ratio (PER). Mortalities, if any, were recorded daily.

Biochemical analyses

Among the various biochemical indicators, proximate composition, amino acids and fatty acids were taken into account to underline the differences in nutritional composition of koi carp under the experimental feeding regime *vis-a-vis* the feeds used. The protein content varied from 158 – 588 g kg^{-1} based on which the feed treatments were numbered as P16, P19, P26, P33, P40, P47, P53 and P59. Gross energy content of these feeds was between 18-19 MJ kg^{-1}.

Proximate composition of feed ingredients and cost (kg^{-1}) (analyzed values on dry matter basis)

Ingredient	CP	EE	CF	NFE	Ash	AIA	Cost (Rs./kg)	Cost US$
Fish meal - Oil sardine	58.36	7.70	0.28	5.96	27.7	0.45	57	1.27
Shrimp meal	68.98	3.42	17.59	3.08	6.93	1.67	60	1.33
Squid	84.75	5.62	4.53	0.31	4.79	0.05	100	2.22
Black clam	67.60	7.52	9.12	0.3	15.46	2.95	100	2.22
Soy flour	52.09	0.51	7.85	6.95	32.6	0.02	65	1.44
Wheat flour	11.15	1.29	0.59	85.13	1.84	0.08	20	0.44
Oil[1]							20	0.44
Vitamin C[2]							950	21.11
Vitamin Mixture[3]							120	2.67
Mineral Mixture[4]							83	1.84
Nutrient additives[5]							9000	200.00
Non-nutrient additives[6]							9216	205.00

[1]Crude sardine oil from Kiriyathan Trading Co. Njarakkal, Cochin, India
[2]Stay – C from DSM Nutritional Products India Pvt. Ltd., Mumbai, India
[3]Supplevite - M manufactured by Jubiliant Organosys Linited, Vadodara, India
[4]Agrimin from Brindavan Phosphates Pvt. Ltd., Bangalore India
[5]Nutrient additives – spirulina and mixed carotenoids
[6]Non-nutrient additives – anti-oxidants and antifungals

Proximate composition of the experimental feeds (g kg^{-1} dry matter) and cost

Feed No.	P59	P53	P47	P40	P33	P26	P19	P16
Crude Protein	588	534	468	401	326	258	190	158
Crude fat	98	84	72	60	65	53	52	55
Soluble Carbohydrates	161	234	332	423	504	604	686	713
Ash	150	141	122	107	93	75	66	63
Acid insoluble ash	1.0	2.0	0.9	0.8	1.1	0.6	0.5	0.4
*Energy (MJ kg^{-1})	19.12	18.72	18.52	18.18	18.18	17.95	17.90	17.79
Cost (kg^{-1})								
INR‘	88.81	81.76	74.71	67.66	60.61	53.56	46.51	43.69
US$	1.97	1.82	1.66	1.50	1.35	1.19	1.03	0.97

*Calculated based on Cuzon and Guillaume (1997): 21.3, 17.2 and 39.5 MJ kg^{-1} of protein, carbohydrate and lipid, respectively; The feed Nos. indicate the protein content in the feeds.

Dry matter losses in these feeds were high in formulations with high levels of protein rich ingredients (P53 and P59), medium in P47 and P40 and least in the remaining feeds viz., P33, P26, P19 and P16. Hydrostability was directly proportional to the wheat flour content in the formulations. Along with this data variations in bulk densities (g l^{-1}) are also presented. Water quality parameters are presented which averaged, temperature 24.25 °C, pH 7.04, dissolved oxygen 7.03 mg l^{-1} and NH_4^+ 0.17 mg l^{-1}.

Amino acid profiles of the all the feeds, along with the initial body amino acid composition and NRC (1993) requirements of common carp are also tabled for comparison. Final body amino acid profiles are also shown. Histidine content of the feeds was met only by feeds P40, P30 and P26. Even though methionine content was deficient in all feeds, methionine + cysteine content was found to be sufficient in all feeds.

Amino acid profiles of the feeds tested (g 100 g^{-1} protein)

Feeds	P59	P53	P47	P40	P33	P26	P19	P16	Initial body profile	NRC Requirements of *Cyprinus carpio* (1993)
Asp	6.58	7.05	5.31	5.89	6.10	6.04	5.24	4.57	6.00	
Glu	10.55	11.11	13.08	11.20	13.00	10.74	16.30	17.75	8.37	
Ser	4.78	4.91	4.05	4.45	4.83	4.56	4.66	4.76	4.25	
Gly	11.16	10.57	11.25	11.94	10.42	12.46	9.44	9.44	14.47	
His	1.55	1.93	1.80	2.05	2.00	2.03	1.86	1.86	1.75	2.1
Arg	5.28	5.95	4.34	5.67	5.58	5.84	4.63	4.27	5.63	4.3
Thr	4.76	4.84	3.55	4.19	4.45	4.47	3.83	3.67	3.94	3.9
Ala	7.47	7.14	7.51	7.25	6.74	7.11	6.01	5.67	8.07	
Pro	6.47	6.03	10.46	8.11	7.80	7.89	10.39	12.01	6.64	
Tyr	3.17	2.34	2.91	2.82	2.53	2.89	2.53	2.52	2.61	
Val	5.34	5.25	5.33	5.31	5.33	5.21	5.34	5.31	4.98	3.6
Met	2.18	2.14	1.76	1.95	1.93	2.01	1.78	1.67	2.23	3.1
Cys	0.44	0.41	0.21	0.38	0.38	0.45	0.27	0.43	0.24	
Ile	4.95	4.69	4.77	4.75	4.56	4.72	4.28	4.19	4.36	2.5
Leu	8.66	8.44	8.38	8.35	8.29	8.38	8.35	8.19	7.31	3.3
Phe	4.41	4.07	4.31	4.37	4.16	4.44	4.18	4.34	3.98	6.5
Lys	11.05	11.59	9.47	10.12	10.51	9.69	9.10	7.51	13.73	5.7
Met+Cys*	2.62	2.55	1.97	2.33	2.31	2.46	2.05	2.10	2.46	3.23

Water quality parameters during the feeding experiment

Parameter	In	Out
Temperature °C	24.25	24.25
pH	6.98	7.11
Dissolved oxygen mgl^{-1}	6.97	7.10
Ammonia mgl^{-1}	0.15	0.20
Nitrite (NO_2^-) mgl^{-1}	0.03	0.09
Nitrate(NO_3^-) mgl^{-1}	13.21	13.71

There is a marked decline in the saturated fatty acids (SFA) and increase in monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) in the feed P16. In the initial and final body composition of fatty acids the trends noticed are, constancy in SFAs from P59 – P26 and a significant decrease in the treatments P19 and P16. In the case of MUFA the body compositions remained similar in treatments P59 to P26 followed by a dramatic increase in the treatments P19 and P16. PUFA contents in the body were found to decrease from P59 to P26 and then increase to a level of 16.82 and 16.94 in the treatments P19 and P16 respectively. The body tissue of the experimental animals fed with P59 and P53 were found to possess significantly higher PUFA (20.63 and 20.88% respectively) than other treatments (<15%).

Effects of feeding formulated feed with ascending levels of protein for a period of 84 days indicates that significant differences were observed in growth and nutrient utilization ($p<0.05$). The trend observed was poor growth with feeds P16 and P19, similar and higher growth with feeds P26, P33 and P40 and a still higher growth with feeds P50 and P59 indicating that feeds containing 26 to 40 percent protein registers similar biomass gain. Significantly higher ($p<0.05$) specific growth rates (SGR) are observed with feeds P46-59. Feed intake as percent of body weight was significantly higher with P59. Food conversion ratios (FCR) were above 2 to close to 2 with feeds P16-33 and with feeds P40-59 FCR's were observed to be below 2. PER's were significantly lower ($p<0.05$) with feeds P33 and P40. Dry matter digestibility (DMD) was significantly less with P59 and similar with all other feeds.

Fatty acid profiles of the feeds tested (g 100 g^{-1} lipid)

Fatty acids	P59	P53	P47	P40	P33	P26	P19	P16	
14:0	8.71	8.95	9.04	9.07	9.80	9.94	10.02	9.72	
15:0	0.27	0.97	0.83	0.86	0.86	0.88	0.93	0.62	
16:0	24.92	24.73	26.32	24.29	24.75	23.87	30.29	13.97	
17:0	1.42	1.29	1.21	0.93	0.83	0.85	0.84	0.27	
18:0	6.72	6.39	5.86	5.50	5.15	5.04	5.70	2.31	
20:0	0.98	0.94	0.93	0.90	0.97	0.95	1.17	0.49	
22:0	0.52	0.21	0.20	0.38	0.35	0.28	0.41	0.20	
24:0	0.08	0.07	0.05	0.13	0.08	0.05	0.07	0.09	
ΣSFA	**43.62**	**43.55**	**44.44**	**42.07**	**42.80**	**41.85**	**49.43**	**27.65**	
16:1ω7	9.64	9.60	9.70	9.15	9.70	9.90	7.90	13.11	
18:1ω9	11.33	11.12	9.32	12.33	10.33	12.60	10.35	18.31	
17:01	0.28	0.73	0.75	0.72	0.76	0.79	0.57	0.22	
20:1n11	0.91	0.87	0.77	1.24	0.06	0.09	0.10	0.00	
22:1n9	1.96	2.13	1.67	1.53	1.32	1.14	0.77	1.08	
ΣMUFA	**24.12**	**24.45**	**22.21**	**24.98**	**22.17**	**24.52**	**19.68**	**32.72**	
18:2n6 cis	3.80	5.39	7.57	9.50	10.59	13.96	13.06	18.40	
18:3n6	1.18	1.06	0.87	1.49	1.20	1.29	1.03	0.80	
18:3ω3	1.00	1.08	1.15	0.11	0.14	0.13	0.11	1.48	
20:2n6	1.83	1.77	1.75	1.65	1.55	1.45	1.02	1.52	
20:3n6	0.07	0.15	0.08	0.19	0.17	0.13	0.16	0.17	
20:4ω6	0.38	0.37	0.38	0.36	0.36	0.29	0.28	0.41	
20:5ω3	7.24	6.87	6.75	6.34	6.18	5.96	4.44	6.21	
22:5ω3	0.30	0.48	0.46	0.40	0.44	0.19	0.29	0.27	
22:6ω3	7.60	7.21	6.76	5.84	5.23	3.86	2.98	3.12	
ΣPUFA	**23.41**	**24.39**	**25.77**	**25.88**	**25.88**	**27.26**	**23.36**	**32.39**	
% fat in dry diet	**9.8**	**8.4**	**7.2**	**6.00**	**6.5**	**5.3**	**5.2**	**5.5**	
ω3 / ω6	2.22	1.79	1.42	0.96	0.86	0.59	0.50	0.52	**Requirement (% dry diet)***
ω3 % of dry diet	1.58	1.31	1.09	0.76	0.78	0.54	0.41	0.61	0.05
ω 6 % of dry diet	0.71	0.73	0.77	0.79	0.90	0.91	0.81	1.17	1.00
DHA/EPA	1.05	1.05	1.00	0.92	0.85	0.65	0.67	0.50	

*Tocher (2010)

Whole body composition of the experimental animals indicated an increase in body protein as protein content in the feeds increased. Fat deposition showed an increase with the ascending level of carbohydrate in the diet with a complementary decrease in the protein content in the formulations.

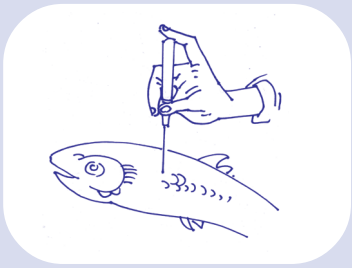
From the growth and feed utilization data, it is evident that, biomass gain is similar with the feeds P33 and P40 and P47 and P53 ($p<0.05$) where P47 and P53 register growth higher than P33 and P40. Similarity in SGRs can be noticed with P33, P40, P47 and P53. Significantly highest growth rate is found with the feed P59 containing almost 60% protein. Bahsir *et al.*, (2010) is the first report to evaluate different level of protein in formulated feeds for Koi carp with levels ranging from 24% to 43%. Since growth was statistically similar with 35% and 43% protein, they opined that 35 – 45% protein would be an economical range. We find that growth increments with ~60% protein without any adverse effects on the growth or health of the fish indicating the adaptive mechanisms inherent to the fish to survive on varying nutrient densities making it

Growth and feed utilization of koi fry (*Cyprinus carpio*) fed with formulated feed with varying nutrient densities

Feed No.	Initial weight (mg[1])	Final weight (mg[1,7])	Biomass gain (mg[2])	Specific growth rate (mg[1,3,6])	Feed intake (% body (wt.[1,6])	FCR[1,4,]	PER[1,5,]	DMD[1,6,7]
P59	149	4000^{a}	3851^{a}	8.21^{a}	0.028^{a}	1.12^{d}	1.61^{b}	92.75^{a}
P53	162	3544^{ab}	3382^{ab}	8.10^{ab}	0.020^{b}	1.14^{d}	2.03^{ab}	93.46^{b}
P47	161	3366^{ab}	3205^{ab}	8.04^{ab}	0.020^{b}	1.08^{d}	2.07^{ab}	94.15^{b}
P40	167	2833^{abc}	2666^{abc}	7.88^{ab}	0.020^{b}	1.31^{cd}	1.96^{ab}	95.23^{b}
P33	157	2702^{abc}	2545^{abc}	7.84^{ab}	0.023^{b}	1.96^{abc}	1.60^{b}	96.79^{b}
P26	146	2511^{bc}	2364^{bc}	7.76^{b}	0.024^{b}	1.46^{bcd}	2.70^{a}	95.90^{b}
P19	163	1654^{bc}	1491^{c}	7.34^{c}	0.022^{b}	2.06^{ab}	2.64^{a}	96.46^{b}
P16	159	1542^{c}	1383^{c}	7.26^{c}	0.020^{b}	2.38^{a}	2.78^{a}	95.78^{b}

[1]Mean values of 3 replicates
[2]Biomass gain = mean final weight – mean initial weight
[3]SGR = (ln mean final weight) (ln mean initial weight) / no. of days
[4]FCR = Dry food fed (mg) / wet weight gain (mg)
[5]PER = Weight gain (mg, wet weight basis) / protein intake (mg, dry weight basis)
[6]DMD = mean dry matter consumed – mean dry matter in faeces/mean dry matter consumed x 100
[7]Mean values sharing the same superscripts are not significantly different ($p<0.05$)

very popular candidate in outdoor garden ponds. Lower digestibility of dry matter with the feeds P53 and P59 indicate a surfeit of nutrients which is lost through faeces. Uniformity in the PER with all feeds except P59 is another indication that a feed with 60% protein can be avoided. Lowest FCR was obtained with feed P47. Feeds P16 and P19 can be excluded because of predictable long term effects of protein insufficiency. Above this level of protein, feeds with protein content 25, 30 and 35% can be advocated as an economical range with all nutrient fortifications and feeds with 40 and 45% protein can be provided as feeds for faster growth. Since high level of carbohydrate utilization was evident, probably due to microflora in the hindgut, different permutations and combinations of protein, carbohydrate and lipid could be examined for an economically optimum level.



Fish Health and Bioprospecting

Pathogen profiling, diagnostics and health management in maricultured finfish and shellfish

Development of a Nested PCR diagnosis for *Perkinsus olseni*

Pearl oysters and edible oysters were screened for the presence of *Perkinsus olseni,* an OIE listed pathogen. Screening methodologies suggested by OIE, the RFTM and first step PCR often failed to detect low infections of *P. olseni* from the oyster populations sampled. In this background, a two step (Nested) PCR was developed as a more specific and sensitive alternative to the OIE suggested conventional diagnostic techniques available.

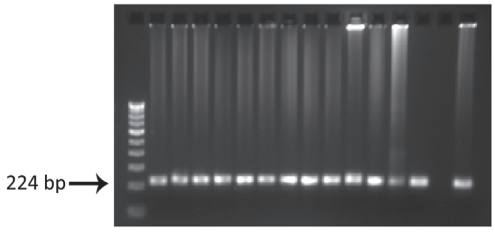
Species specific primer sets were designed from the sequence information generated and PCR protocols were developed and standardized.

For the first step PCR, the ITS region (~700 bp) of *Perkinsus* sp. was amplified using *Perkinsus* genus specific ITS primers, ITS-85 (52 -CCG CTT TGT TTG GGA/C TCC C-32) and ITS-750 (52 -ACA TCA GGC CTT CTA ATG ATG-32) under the following thermocycler conditions: an initial denaturation at 95 °C for 3 min, denaturation at 94 °C for 30 s, annealing at 60 °C for 30 s, extension at 72 °C for 45 s, repeated for 39 cycles, followed by a final extension for 3 min at 72 °C.

For nested PCR , internal primers were designed using the program Primer3 (v. 0.4.0).To increase the specificity of the nested primer within the genus *Perkinsus*, the forward primer has been designed specifically from the conserved 5.8S ribosomal RNA gene and the reverse from internal transcribed spacer 2 (ITS 2) regions. Forward primer - PerkITS65: 5' ACGATGGATGCCTCGGCTCG 3' and the Reverse primer - PerkITS288: 5' TCCGAAGAGTTAGTCCAAGCGGGA, and the product length was 224 bp.

Nested amplifications were performed in 25 µl reactions containing PCR buffer (SIGMA, USA) at 1× concentration with 1.5 mM $MgCl_2$, 5 pmol of each primer (forward and reverse internal primers), 0.2 mM of each dNTP, 1.5 U Taq DNA polymerase (SIGMA, USA) and 1 ìl from the first step PCR amplified mix as template DNA. Thermocycler conditions: initial denaturation at 95 °C for 1 min, denaturation at 95 °C for 30 s, annealing at 58 °C for 30 s, extension at 72 °C for 30 s, repeated for 34 cycles, followed by a final extension for 3 min at 72 °C.

Screening the bivalve population using the newly developed nested PCR clearly showed the advantage and efficacy of the technique over the conventional methods



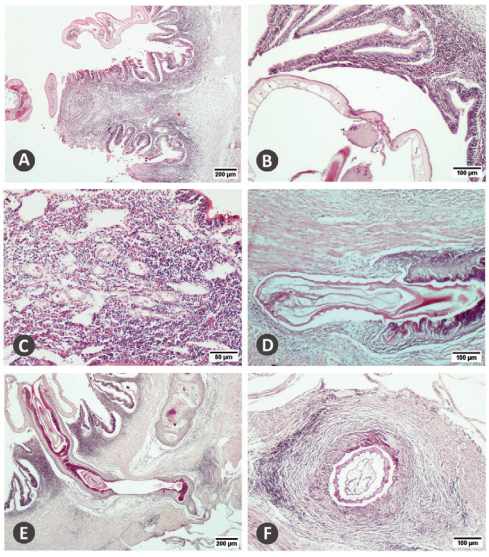
224 bp nested PCR product specific to *P. olseni*

Comparison of RFTM, first step PCR and nested PCR tests for *P. olseni* in *C. madrasensis*

Location	No.of samples	RFTM positive	PCR positive –Ist Step	PCR positive Nested
Tuticorin	75	22	9	36
Kollam	40	8	nil	36
Cochin	40	2	1	32
Kozhikode	16	1	nil	11

The results clearly show that the nested PCR can detect infections which could not be diagnosed using RFTM and first step PCR.

Out of 171 *C. madrasensis* samples collected from Tuticorin, Kollam, Cochin and Kozhikode, only 43 (25%) tested positive with the OIE suggested methods, RFTM and first step PCR while 115 (67%) tested positive for *P. olseni* with the nested PCR indicating the sensitivity, specificity and speed of this newly developed, DNA based diagnostic test for the screening of *P. olseni* infections in bivalves. This nested PCR could be suggested as the confirmatory test for *P. olseni* along with RFTM. This nested PCR is being used for the epidemiology studies of *P. olseni* among the cultured bivalves.



A & B - hyperplasia and compression of villi; C - proliferation of blood vessels; D - granular tissue formation; E - parasite traversing the intestinal wall and F - fibrous connective tissue capsule around the parasite

Studies on the host range

Following the report of *Perkinsus olseni* in pearl oysters (*Pinctada fucata*) from the south-east coast of India, studies were made to screen other species of bivalves for *P. olseni* infections. Molecular diagnostic studies using first and second step PCR revealed that the pathogen enjoys a very wide host range. Altogether, *P. olseni* infections were observed in ten bivalve host species from the Indian subcontinent. The wide host range of the parasite observed during the study indicates the necessity of an assessment of the parasite among the commercially important bivalve population in the Indian subcontinent.

Host range of *P. olseni* in the bivalve population from the Indian subcontinent

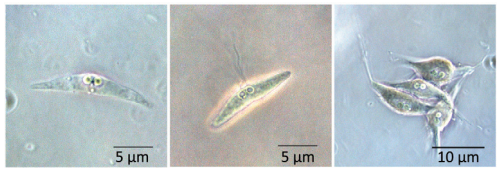
Host Species	Location	Diagnosis	
		1st step PCR	Nested PCR
Pinctada fucata	Tuticorin	"	"
Pinctada margaritifera	Andaman & Nicobar islands	_	"
Crassostrea madrasensis	Tuticorin, Cochin, Kollam & Calicut	"	"
Saccostrea cuculata	Calicut & Thalassery	_	"
Isognomon sp.	Calicut	_	"
Perna virdis	Calicut	_	"
Pinna sp.	Tuticorin	"	"
Meretrix casta	Calicut	"	"
Paphia malabarica	Tuticorin	"	"
Gelonia gelonia	Azhikode	_	"

Acanthocephalan infections in finfishes

The study of the acanthocephalan infection in red snapper, *Lutjanus argentimaculatus,* a candidate species for mariculture, was continued.

The parasite was identified as *Tenuiproboscis* sp. and this forms the first report of *Tenuiproboscis* sp. in *L. argentimaculatus.*

Heavy infection with the parasites were observed in the posterior region of the intestine, almost blocking the lumen of the intestine. Histopathology studies revealed severe alterations at the tissue level including compression, abrasion and desquamation of mucosal epithelium and thickening of lamina propria. Detachment of epithelial cells, ruptured capillaries, enlargement and proliferation of blood vessels, dilation of lymphatic vessels and hyperplasia of intestinal villi were noticed. The proboscis was seen traversing the entire breadth of the intestinal wall and reaching the peritoneal cavity, enclosed in a fibrous connective tissue jacket of host origin. Inflammation, granular tissue formation, connective tissue proliferation and associated host immune reactions were evident in the tissues. The studies revealed severe pathological changes and the mechanical damage caused by the parasites which destroyed the total architecture of the intestinal tissues of the host. These changes can drastically reduce the absorptive area available for the digestive and absorptive functions of the fish.



Spores and developmental stages of *Ceratomyxa* sp. reported from the gall bladder of *L. argentimaculatus*

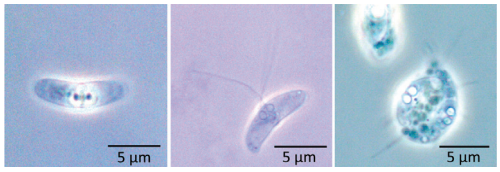
Partial sequence of *Tenuiproboscis* sp. from *L. argentimaculatus* was done and phylogenetic tree constructed which indicated its position among the other acanthocephalans for which sequence data is available in the Genbank. Sequence data for the genus *Tenuiproboscis* does not exist in NCBI and this forms the first sequence information on *Tenuiproboscis* with evident pathological manifestation. The host range of *Tenuiproboscis* sp. was studied and included *Epinephelus malabaricus, Lates calcarifer* and *Scatophagus argus*. All the parasite samples from different hosts and geographical regions were subjected to molecular taxonomic analysis which showed that they are all genetically similar and hence confirmed as *Tenuiproboscis* sp.

Gene/DNA sequence submissions of *Tenuiproboscis* sp.

1	*Tenuiproboscis* sp. TpEm01 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	JF694273
2	*Tenuiproboscis* sp. TpLa01 internal transcribed spacer 1, partial sequence; 5.8S ribosomal RNA gene, complete sequence; and internal transcribed spacer 2, partial sequence.	JF694277
3	*Tenuiproboscis* sp. TpLa01 18S ribosomal RNA gene, partial sequence	JF694275
4	*Tenuiproboscis* sp. TpLa01 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial	JF694276
5	*Tenuiproboscis* sp. TpEm01 internal transcribed spacer 1, partial sequence; 5.8S ribosomal RNA gene, complete sequence; and internal transcribed spacer 2, partial sequence.	JF694274

Protozoan parasitic infections in finfishes

Infection with the Myxosporean parasite was reported from *L. argentimaculatus* collected from Cochin. The parasite belongs to the genus *Ceratomyxa* and forms the first report of a *Ceratomyxa* from *L. argentimaculatus*. Infected gall bladders appeared swollen with dark, viscous bile filled with spores, pansporoblasts and other developmental



Spores and developmental stages of *Ceratomyxa falcatus* reported from the gall bladder of *Abudefduf bengalensis*

stages. Morphological and morphometric data indicate that the species has not been described earlier. Molecular taxonomic studies are underway to confirm the taxonomic status of the species.

Infection with the myxosporean parasite was also reported from the gall bladder of the ornamental fish, *Abudefduf bengalensis* collected from the southwest coast of India. Morphologically and morphometrically (smallest reported spore size), the parasite appears to be distinct from all other reported species of *Ceratomyxa.* But molecular taxonomy studies showed the species to be similar to *C. falcatus* reported from Australian waters with a mean pairwise genetic distance of only 0.3%. This is a typical case of morphological plasticity where the species appears to be totally different morphologically and morphometrically while genetically showed very close similarity to *C. falcatus*.

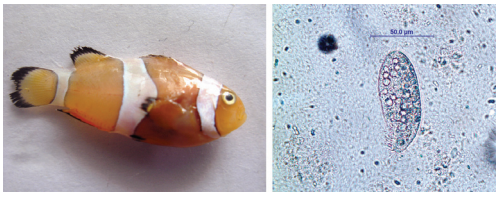
Amphiprion nigripes infected with metacercaria of *Prosorhyncus* sp; metacercarial cysts in the finrays

Protozoan parasitic infections in ornamental fishes

Five species of clown fishes viz. *Amphiprion ocellaris, A. seba, A. percula*, *A. nigripes, A. clarki* and *Premnas biaculeatus* maintained in the hatchery at Vizhinjam were monitored for the presence of disease conditions. Mortality was observed in the brood stock of *Amphiprion nigripes* due to metacercareae of the digenean, *Prosorhyncus* sp. in gills and muscles. Treatment was attempted using praziquantel 10 mg g^{-1} in feed followed by bath in 2 mg l^{-1} for 1hr.

Mortality observed in sub-adults of *Amphiprion ocellaris* was investigated. The fishes were restless and showed symptoms of itch disease. The infected fishes were covered with a thick mucous layer and died within a day. Microscopical examination of skin and gills of dead fishes revealed the infection with the ciliate protozoan, *Brooklynella hostilis*. *B. hostilis* infection is popularly known as clownfish disease and this forms the first confirmed report of this disease from India.

Bacterial infections in cage reared Asian seabass *Lates calcarifer*



Amphiprion ocellaris infected with *Brooklynella hostilis*; *Brooklynella hostilis* in mucus

Incidence of Vibriosis in Asian seabass (*Lates calcarifer*), from the cage farms of CMFRI at Karwar was studied. The external lesions included haemorrhages and ulcers on the body surface while histological studies revealed extensive haemorrhage, degeneration and necrosis in vital organs. The 16S rRNA amplification and sequencing revealed that the etiological agent to be *Vibrio alginolyticus*. This is the first report of Vibriosis caused by *V. alginolyticus* in Asian seabass reared in open sea floating cages from Indian waters.

Health monitoring in hatchery reared lobsters

Wild broodstock of spiny and sand lobsters were examined for presence of vibrios. Results indicated the presence of vibrio infection in sand lobster broodstock. Mortalities were observed in *Panulirus homarus* juveniles at elevated temperature at 29 – 30 ^{o}C, the symptoms resembled Gaffkemia and further studies are required for confirmation. Gill rot was noticed in 40-50 mm CL sand lobsters due to suspected fungal infection in the gills. A condition of "Moult Death Syndrome" was noticed in sand lobsters stocked in high densities.

Bacterial abundance was investigated in water from the different sources of sump, reservoir pump input, rapid sand filter and wet lab. The bacterial load was high in the sump (5.8 X 10^4) reservoir (5.7 X 10^4) and pump input (5.5 X 10^4), whereas the bacterial load was lower in

the wet lab (3.5 X 10^3) which was treated through rapid sand filter. The study indicated the possibility of the bacterial introduction when untreated sea water is used for hatchery rearing.

Regular monitoring of ammonia, nitrate and H_2S was carried out in broodstock tanks of *Panulirus homarus, P. ornatus. P. polyphagus* and *Thenus orientalis* for a period of six months. The ammonia values were maximum (3.094 mg /l) in the lobster hatchery input water whereas the nitrate(0.969 mg/l) and hydrogen sulphide (0.060 mg/l) values were maximum in the new hatchery out put water.

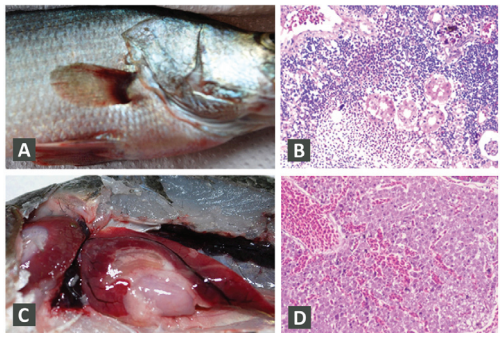
A DNA based diagnostic test using nested PCR was developed for the diagnosis of *P. olseni* infections in bivalves. This technique has high sensitivity and specificity and can detect infections which could not be diagnosed using conventional techniques like RFTM and first step PCR. This nested PCR could be suggested as the confirmatory test for *P. olseni* along with RFTM. A user friendly nested PCR kit is under development.

Molecular diagnostic studies revealed that *Perkinsus olseni* enjoys a very wide host range and infects ten bivalve host species from the Indian subcontinent. Sequence information generated for the first time in *Tenuiproboscis* sp. an acanthocephalan parasite infecting the red snapper, *L. argentimaculatus.*

First report of *Ceratomyxa* sp., a myxosporean parasite from the gall bladder of the red snapper, *L. argentimaculatus.*

First report of Vibriosis caused by *V. alginolyticus* in Asian seabass reared in open sea floating cages from Indian waters.

First confirmed report of *Brooklynella hostilis,* a ciliate protozoan infection in *Amphiprion ocellaris* from India.



Pathological changes by *Vibrio* infections in seabass: A - Haemorrhage at the base of the pectoral fin; B - Haemorrhage and necrosis of the kidney parenchyma; C - Necrotic areas on the liver and congested kidneys; D - Severe haemorrhage in the liver

Development of cell lines

Three successful cell lines EM4SpEx, EM2GEx and EM3G Ex have been developed from the spleen and gill tissues of the Malabar grouper, *Epinephelus malabaricus* with 148, 128 and 152 passages respectively. The Em4HTr derived from trypsinised heart tissue has reached up to 52 passages. Three successful cell lines, DT1CpEx, DT1F4Ex and DT1CPTr were developed from the various tissues of *Dascyllus trimaculatus* with 89, 91 and 93 passage levels, six cell lines from *Rachycentron canadum* nine from *Epinephelus merra* and three from the rabbit fish *Siganus canaliculatus* were also successfully developed.

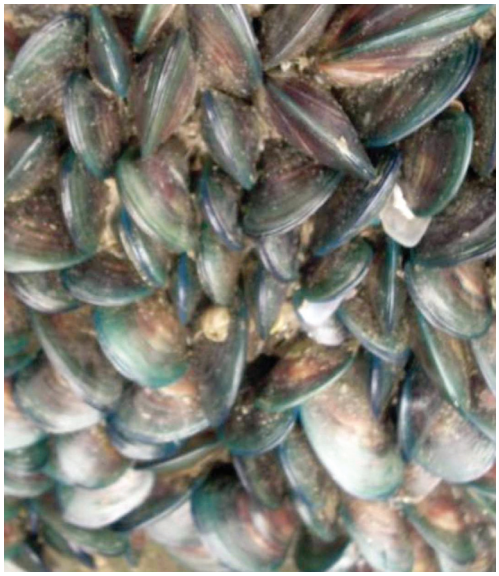
BIOPROSPECTING

Evaluation of green mussel (*Perna viridis* L.) from wild and cultured conditions for anti-inflammatory and nutritional properties

Neutraceutical (GMe) from green mussel

Screening green mussel (*Perna viridis* L.) grown under wild and cultured conditions for anti-inflammatory activities and nutritional composition provided valuable information of the species grown under cultured conditions for use as anti-inflammatory supplement. Green mussel (*P. viridis*) samples were collected from south-west coast of India (Kozhikode, Elathur (11^0 54' 11.6" N;75^0 12'.21.8'' E).

Maricultured green mussel exhibited higher protein content (141-236 mg/100 g) than that of wild (72-183 mg/100g) samples. The wild *P. viridis* registered higher lipid content than cultured samples. Minerals like Zn, Mn and Cu, which are known as essential elements, were found to be abundantly available in the maricultured wild green mussels. All *trans* retinol underwent no significant fluctuations, though a higher content of this vitamin was apparent in wild (8.2 IU) than in cultured (5.3 IU) samples. Phylloquinone (K1) registered higher values in maricultured samples (2.2 µg/100g) than in wild (1.26 µg/100g), whereas vitamin C exhibited a reverse trend (9.89 vs 12.74 IU, respectively). Cholecalciferol (D_3) was found to be significantly higher in cultured *P. viridis* (412 IU), than in wild samples (352 IU).



Green mussel *Perna viridis*

Nutritional composition of green mussel (*Perna viridis*) harvested under wild and cultured conditions from Kozhikode during May-June

Proximate compositions (% wet weight)	Wild	Cultured
Lipid (%)	2 ± 0.13	1.7 ± 0.16
Cholesterol (mg/100g)	96.6 ± 0.78	65.1 ± 1.32
Protein (mg/100g)	103.9 ± 0.67	220.3 ± 1.83
Vitamins (IU)		
Retinol (A)/IU	8.2 ± 0.15	5.31 ± 0.09
Cholecalciferol (D2)/IU	352.5 ± 4.39	412.8 ± 2.56
Tocopherol (E)/IU	0.13 ± 0.01	0.12 ± 0.01
Phylloquinone (K1) (µg/100g)	1.26 ± 0.02	2.2 ± 0.149
Ascorbic acid (C)/IU	12.74 ± 0.15	9.89 ± 0.09
Amino acids	**Amino acid (as mg/100g)**	
Σ Essential amino acids/E	1462.9	1631.8
Σ Non- essential amino acids/NE)	1320	2204.1
Fatty acid (as weight %)		
Σ Saturated fatty acids	30.28	34.41
Σ Monounsaturated fatty acids	27.29	27.26
Polyunsaturated fatty acids (% TFA)		
20:5n3 (EPA)	12.84 ± 1.04	12.68 ± 1.15
22:6n3 (DHA)	9.87 ± 0.96	9.60 ± 0.12
Σ PUFA	35.00	31.51

The ratio of essential (E, g/100 g protein) / nonessential (NE, g/100 g protein) amino acid was 0.7 (for cultured) to 1.1 (for wild). *P. viridis* have well-balanced and high-quality protein source in respect of E/NE ratio in all seasons.

The samples collected from North Malabar region of Kerala have significantly lower SFA (30-34%), and a significantly higher PUFA content (32-35%) in either growth conditions. No significant differences were apparent in wild and cultured samples. No significant differences were recorded in the content of EPA and DHA, the *n*-3 PUFAs required essentially by human beings between the samples harvested under wild and cultured conditions.

Anti-inflammatory properties of *P. viridis*

Inflammation is the pathophysiological response of mammalian tissues to a variety of hostile agents, and the complex events and mediators

involved in inflammation can induce, maintain and aggravate many disorders including arthritis, diabetes, and cancer. Current treatment options are mostly symptomatic and include Non Steroidal Anti-Inflammatory Drugs (NSAIDs) for pain relief but fail to block the progression of the disease.

The reported side-effects and contra-indications of current AI drugs have lead to investigations into natural products for safer and more effective alternatives. Green mussels are commercially valuable species, easy to cultivate or collect in coastal areas, and are reported to effectively control arthritic inflammation.

In Cadalmin™ GMe, unique biochemical engineering has been used to identify the active components and to concentrate them in the product. Cadalmin™ GMe has sustained activity, no toxicity, less leachability. This product is an effective green alternative to synthetic NSAIDs (*viz.,* aspirin containing drugs having undesirable side effects). Cadalmin™ GMe is designed to find a unique way to prevent the degradation by air, moisture, heat and light and to maximize the activity. The product is free from deleterious *trans* fatty acids, free radicals/free radical adducts, and low molecular weight carbonyl compounds.

The active principles in Cadalmin™ GMe isolated from *P. viridis* inhibit inflammatory $COX_{I, II}$ and LOX_V in an inflammation and oxidative stress reaction, resulting in decreased production of inflammatory prostaglandins and leukotrienes, and its activity was found to be superior to the synthetic non steroidal anti-inflammatory drugs available in the market.

It was found that the active principles isolated from *P. viridis*, and concentrated in the product registered higher COX_{II} and LOX_V inhibition (70-75%) than aspirin and indomethacin (55-66%, 5mg/ml). In vivo animal model studies revealed that the active principles effectively suppressed (64 and 77%, 2-4 h) the edema produced by the histamine, which indicates that they exhibit its anti-inflammatory action by means of either inhibiting the synthesis, release or action of anti-inflammatory mediators.

This product has been developed as capsules and packaged in food grade polypropylene bottles. Cadalmin™ GMe is an indigenous product, and is highly cost effective compared to imported products available in the market. The product know-how has been patented, and efforts are underway to commercialise this product as an import substitute.

Product from green mussel - GMe

Antibacterial labdane diterpenoids of *Ulva fasciata* Delile from southwestern coast of the Indian peninsula

Seven labdane derivatives (secondary metabolites), namely labda-14-ene-8-ol (1), labda-14-ene-3a,8a-diol (2), labda-14-ene-8a,9a-diol (3) labda-14-ene-8a-hydroxy-3-one (4), ent-labda-13(16),14-diene-2-one (5), ent-labda-13(16),14-diene-3a-ol (6), and ent-labda-13(16),14-diene-3a-ol (7), were isolated as major constituents of *U. fasciata* (Chlorophyceae).

Structures of these secondary metabolites were established using spectroscopic analysis, especially IR, mass, and NMR spectra, in conjunction with 2D NMR experiments. The relative stereochemistry

was assigned on the basis of a study of the coupling constants and NOESY experiments.

The in vitro antibacterial activity of these secondary metabolites was evaluated against fish pathogenic bacteria, namely *V. parahaemolyticus* MTCC 451, *V. alginolyticus* MTCC 4439, and *V. vulnificus* MTCC 1145. The antibacterial assay revealed that labdane derivatives (1–4) were superior to ent-labdane derivatives (5–7).

Antimicrobial assay showed that the compounds labda-14-ene-3a,8a-diol (2) and labda-14-ene-8a-hydroxy-3-one (4) were inhibitory to the growth of *Vibrio parahaemolyticus* and *V. alginolyticus* with minimum inhibitory concentrations of 30 µg ml^{-1} by 2, and 40 µg ml^{-1} by 4, respectively against the former and 30 µg ml^{-1} by 2, and 80 µg ml^{-1} by 4, respectively, against the latter.

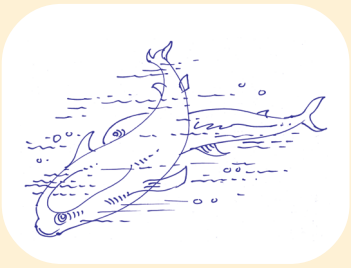
Structure–activity relationship analyses revealed that the compounds with electronegative hydroxyl or carbonyl group(s) exhibit greater activities, apparently by proton exchange reaction with the basic aminoacyl residue at the macromolecular receptor site of virulent enzymes of pathogenic bacteria. These might provide promising therapeutic agents against infections with multi-resistant Gram-negative fish pathogenic bacteria.

PUFA concentrate (O3) from marine fish body oil

Polyunsaturated fatty acid concentrates from green mussel *Perna viridis* and their potential against inflammatory enzymes

Physico-chemical procedures were used to concentrate PUFAs from SFAs and MUFAs resulting in reduction in SFAs (72.2% to 39.2% TFA). The total PUFA after fractionation stage -2 was recorded to be 34.62%, mainly comprising by EPA (9.8% TFA), 18:3 n3 (2.61 % TFA), and 22:6 n3 (10.1% TFA).

The n3 PUFA concentrate (O3) prepared in the laboratory was found to inhibit cyclooxygenases (COX) by acting as competitive substrate inhibitors. O3 registered significantly higher COX-II inhibition (68.2%) than aspirin and indomethacin (58.6 % and 59 %, respectively, at 5mg/ml), where as in lower concentration (0.5 mg/ml and 1 mg/ml) O3 (31.2% and 55.6%, respectively) showed lower COX-II inhibition as compared to aspirin and indomethacin. O3 (56.30%) showed significantly higher (lysyl oxidase) LOXV inhibition than aspirin (in 5 mg/ml) but lower than indomethacin. Interestingly in lower (1 mg/ml) concentration O3 (51.60%) recorded higher LOX-V inhibition than indomethacin (47.20± 0.17%).

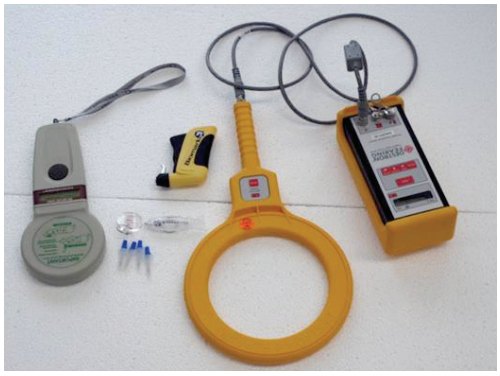


BROODSTOCK DEVELOPMENT

Finfish

Cobia *Rachycentron canadum*

A total of 37 cobia brooders of size ranging from 12 to 35 kg weight were maintained in five cages in the Gulf of Mannar at a stocking density of 1.5 kg per m^3. The fish were fed daily with 70% of fresh sardines and 30% portunid crabs/ squid at 5 % of their body weight. Vitamins A & E, PUFA (fish oil, squid oil, krill oil, cod liver oil, *etc.*) and mineral mixtures were also supplemented the regular diet. The brood fishes were cannulated at specific intervals to assess the gonad maturity to decide upon induction of spawning.



PIT (Passive Integrated Transponder)

PIT tagging of cobia broodstock at Mandapam

Passive Integrated Transponder (PIT) was employed for tagging the cobia broodstock at Mandapam Regional Centre during current year. Tagging is useful in getting the reproductive history of the brooder reared in cage.

Experiments conducted on inducement of spawning

Date	Weight of brooders (kg)		Sex ratio	Hormone type & dosage	Results
	Male	Female	(M:F)		
10.07.2010	9.0 & 15.0	20.0	2:1	hCG 500 IU per kg body weight for females and 250 IU per kg body weight for males	Spawning occurred after 42 hours of hormone administration, but the eggs were very few and unfertilized
29.08.2010	17.5 & 15.5	25.0	2:1	hCG 500 IU per kg body weight for females and 250 IU per kg body weight for males	No spawning occurred up to 72 hours.
16.12.2010	11.0 & 20.0	25.0	2:1	hCG 500 IU per kg body weight for females and 250 IU per kg body weight for males	Spawning occurred after 48 hours of hormone administration, but the eggs were unfertilized and the total quantity of eggs estimated was 1.3 million
06.01.2011	22.0 & 23.5	23.0	2:1	hCG 500 IU per kg body weight for females and 250 IU per kg body weight for males	Spawning occurred after 52 hours of hormone administration, but the eggs were unfertilized and the total quantity of eggs estimated was 0.7 million

A method was developed for the transportation of cobia in which a flow-through system works by utilizing the speed of the vessel. Fishes were collected by hook and line and were transported in the polythene

Inserting the tag to cobia broodstock

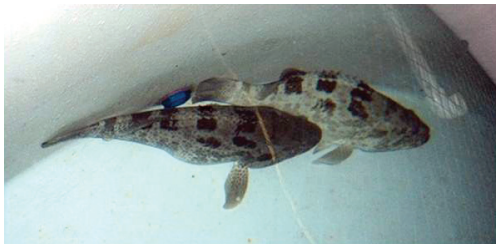
lined bottom cabin of boat itself. If more numbers were obtained they were transported to shore using large rectangular polythene tanks. Two pipes were kept in the tanks for water circulation. Water was allowed to pass into the tank through the inlet tube which is placed against the current created by the boat while moving and excess water was drained off by the outlet pipe. Thus without using any aerators, fishes were transported to the cage without any stress. Injured fishes were treated using betadine ointment (external application). This was found to give better survival (90%) and healthy animals compared to transportation using battery operated aerators. More than 45 cobia of size ranging from 1 to 5 kg were collected from hook and line catches, stocked in cages and fed with different broodstock diets.

Pompano *Trachinotus blochii*

Thirty numbers of *T. blochii* brooders weighing from 1.5 to 2.5 kg are being maintained in a cage installed in the Gulf of Mannar. The fish are being fed with fresh sardine @ 5% body weight supplemented with vitamins, PUFA and minerals.

Inducement of spawning

Four experiments on induced spawning were conducted on 17th August 2010 (oocyte size: 200-400µm; hCG 250 IU per Kg), 25th September 2010 (oocyte size: < 100 µm; GnRH 5 µg per Kg), 8th October 2010 (oocyte size: < 350 µm; GnRH 4 µg per Kg), and 2nd March 2011 (oocyte size: 400-500µm; hCG 250 IU per Kg). Eventhough spawning occurred during the above experiments, the eggs were unfertilized.



Grouper brooders ready to spawn

Greasy grouper *Epinephelus tauvina*

Greasy grouper *Epinephelus tauvina* of 2.0 to 5.0 kg were collected from commercial catches at Visakhapatnam. Male broodstock was developed by inducing sex reversal through hormonal manipulations at the hatchery and female broodstock was developed in open sea floating cage. The fishes were fed twice in a day with squid.

One matured female of 4.0 kg with ova diameter of 400-450 µm and one sex reversed male of 4.5 kg were employed for spawning experiment. Split doses of hCG and LHRHa for 5 consecutive days were administered. The floating eggs were noted 24 hours after the last dose of hormone.

Malabar red snapper *Lutjanus argentimaculatus*

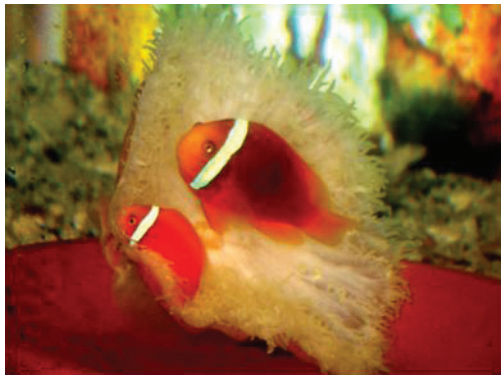
Thirty numbers of *L. argentimaculatus* of 1 to 2.3 kg size were collected from the estuarine environment. The fishes were reared in 10 ton tanks provided with biological filter at Kandakkadav. After rearing for three months, the fishes attained a weight of 2.0 to 3.5kg.Another set of 90 numbers of *L. argentimaculatus* of size ranging from 1.5 to 2 kg were reared in brackishwater cage at Gothuruthu, Cochin. In both the cases, fish were fed with sardine, squid, green mussel, clam meat *etc.*

Broodstock of *Lutjanus argentimaculatus*

At Calicut, 20 numbers of *L. argentimaculatus* broodstock weighing 1.2 to 3 kg were daily fed *ad libitum* with fresh tuna meat. Everyday 30% of the seawater is exchanged from the tanks fitted with filtration system. Around 200 nos. of *L. argentimaculatus* ranging in size from 200g to 1.2 kg are being maintained in sea cages at Karwar by feeding twice a day with oil sardine @5% body weight.

Ornamental fishes

The broodstocks of *Amphiprion nigripes*, *A. clarkii* and *A. frenatus* were successfully developed at Kochi and Vizhinjam.



Brooders of *Amphiprion frenatus*

Pair formation and broodstock development of *A. frenatus* were carried out under captivity. For this, 5-6 numbers of juveniles of different age groups were reared in 500 l FRP tanks along with one host sea anemone *H. magnifica* to mimic the natural environment and also to reduce the aggression. The fishes and anemones were fed twice a day with shrimp meat, green mussel and clam meat @ 10 % body weight and, live feeds like *Brachionus plicatilis* and newly hatched *Artemia* nauplii. All tanks were fitted with biological filters, and the temperature was maintained between 27 and 29°C, using aquarium heaters. Temperature was monitored with thermal sensors round the clock. Salinity (32 to 34 ppt), dissolved oxygen (4.6 to 6.2 ml/l), pH (8.0 to 8.5) and photoperiod 12L:12D were maintained and once in a week 25% of the water was exchanged. After a rearing period of 3 to 5 months, one pair in each tank grew ahead of others and became the monogamous pair. The standard length of the (presumptive) female varied between 100 and 130 mm and that of the (presumptive) male varied from 55 to 60 mm and the pairs thus formed were then transferred to broodstock tanks. Through pair formation experiment six pairs of *A. frenatus* were developed. Adopting similar methodology, the broodstocks of *A. nigripes* and *A. clarkii* were also developed.

Breeding pair of *A. clarkii*

At Mandapam the broodstock development of red saddleback or fire clown, *Amphiprion ephippium* was initiated. The pair formation was noted and feeding with broodstock feeds is being continued.

Fire dart fish, *Nemateleotris magnifica* and scissortail dart fish, *Ptereleotris evides* were also selected for broodstock development. The juveniles of *N. magnifica* reached 5 to 6 cm in one year. Whereas, the juveniles of *P. evides* attained 10 to 12cm in one year. Purple firefish goby *Nemateleotris decora* and engineer goby *Pholidichthys leucotaenia* were the other species selected for broodstock development. The breeding pairs of *N. decora* were developed and bred successfully in captivity.

Shellfish

Lobsters

Broodstock of spiny lobsters (*P. homarus, P. polyphagus, P. ornatus P. versicolor*) and sand lobster *(Thenus orientalis*) were reassembled in the recirulatory system, requiring less water exchange. *P. homarus* and *P. ornatus* have shown good response to the new recirculatory tank facilities with growth and survival rates at high densities. Two trial runs of *P. ornatus* larvae were made from the broodstock developed in the rearing systems at the laboratory. However, *Vibrio* infections still remain as a bottleneck for successful completion of the larval cycle. UV and ozone treatments of the water systems are being tested to address this problem.

Broodstock of *Pholidichthys leucotaenia*

Gastropods

Fresh collection of brooders of *Chicoreus ramosus* (14 nos.) size/ weight ranging from 114.2-200 mm/290-750g were made and maintained in the shellfish hatchery. Observations on the feed protocol for brood

Thenus orientalis broodstock rearing system

Broodstock fattening experiment of *Perna viridis*

maintenance were made. Average of 150 g of live clam/day is required for maintenance of healthy brooders.

Ten numbers of tiger cowries *Cypraea tigris* size ranging from 75.2 to 98.3mm and 185 to 300 g were maintained in the shellfish hatchery. The brood maintenance tank was rectangular one ton FRP with 750 l water and airlift system for replacement of 300 times over 24hrs.

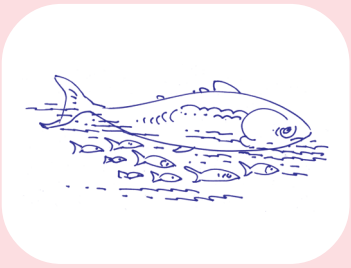
Twenty four *Lambis lambis* brooders size/weight ranging from 148 to 184 mm and 50 to 400 g were maintained for breeding. The broodstock tank was rectangular one ton FRP with 750 l water and airlift system for replacement of 300 times over 24 hrs with algal feed *'ad libitum'*. The system was effective with continued maintenance and captive breeding for this species was successful with nil mortality over a year period.

Black-lip pearl oyster *Pinctada margaritifera*

Over 50 numbers of *P. margaritifera* spat was collected from Lawson's Bay during February 2010. However, only 15 survived and these were reared in the hatchery. They were maintained on *Isochrysis galbana* and *Chaetoceros calcitrans*. The spat attained an average of 48. 72 mm DVM, 37.28 APM, 11.92 mm thicknness and 16.86 g total weight in 290 days from an initial average of 15.63 mm DVM, 15.62 mm APM and 0.40 g. Male gonadal development was observed at 45 mm DVM.

Green mussel *Perna viridis*

Broodstock from Thikkodi area which is least polluted area of Calicut District was selected and kept in temperature controlled area and fed with *Isochrysis galbana* and also mixed algal diet by drip feeding, for breeding experiments.



Seed Production

Cobia *Rachycentron canadum*

Greenwater technique was adopted for larviculture. The live feeds required for larviculture were mass cultured and enrichment procedures were standardised.

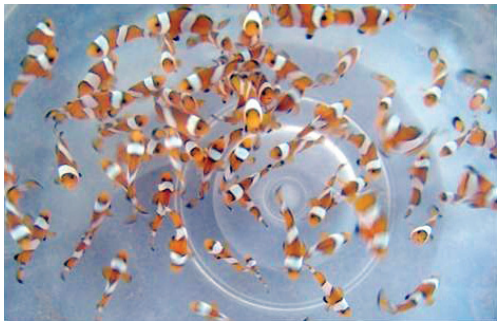
Larviculture protocols were developed by appropriate management of live feeds in required quantities and also taking into consideration the nutritional requirements of the larvae. The larvae were stocked in FRP tanks of 5 ton capacity for larviculture. The larviculture tanks were provided with green water at a density of about 1x 10^5 cells per ml and rotifers enriched with DHA SELCO at a density of 6-8 nos. per ml from 3 to 9 dph. The critical stage for the larvae was 5 to 7 dph when they entirely resorted to exogenous feeding from yolk sac feeding. During this period, about 80% mortality was noted.

Fingerlings from the nursery rearing tank in the hatchery

From 9 to 21 dph, the larvae were fed four times daily with enriched *Artemia* nauplii by maintaining a nauplii concentration of 2-3 nos. per ml. During this period, co-feeding with rotifers was also continued due to the presence of different size groups of larvae.

From 18 dph onwards, the larvae were fed with newly hatched *Artemia* nauplii and weaning to larval inert feeds was also started .The size of weaning feeds used were 100-200 µm for 18-19 dph larvae of size 2.3 -2.5 cm, 300-500 µm for 20-23 dph larvae of size 2.5 to 3.5 cm, 500-800 µm for 23-30 dph larvae/juveniles of size 3.5 to 8 cm and 800-1200 µm for 31 dph onwards.

From 25 dph, grading of larvae was started. The shooters were fed exclusively with the artificial feed of the size 500-800 µm and 800-1200 µm.



Amphiprion percula

Nursery rearing of fingerlings was done in two phases. The first phase was done in 5 tonne capacity FRP tanks in the hatchery. About 250 numbers of fingerlings were reared in each 5 tonne tank which was filled at two-third level with sea water. Almost 100% water exchange was done in the morning and evening. They were fed both by formulated feeds as well as with chopped sardines. The hatchery phase of nursery rearing was continued for a month and when the fingerlings reached a length range of 17-22 cm and weight range of 27-59 gms, the fingerlings were transferred to nursery cages which were installed in the nearshore area.

The second phase of nursery rearing in cages was done for about 20 days. During the period, they were fed with chopped trash fish. At the end of this nursery phase, the length range of fingerlings was 22-26 cm and weight range 35-70 g.

Pseudodiaptomus serricaudatus female

Acclimatisation and transportation of seed

Experiments were conducted on transportation trials in seed/juveniles of sea bass, mullet *Mugil cephalus*, rabbit fish *Siganus* spp. and silver biddy *Gerres filamentosus*.

Acclimatisation to 2-3°C less temperature and starvation on the day prior to transportation gave better performance and survival of seed stocks.

Various concentrations of Aqui-S (clove oil) comprised primarily of iso-euganol were tested as an anaesthetic for transport. Doses of 1-5 ppm were found to give good results for transport (low toxicity, safe and effective), except for mullets.

Ornamental fish

Mass seed production of *Chrysiptera cyanea*, *Dascyllus aruanus and Pomacentrus caeruleus*, *Amphiprion ocellaris*, *A. percula, A. sebae* and *Premnas biaculeatus* were carried out. An amount of Rs.3,06,900/- was generated during the report period.

Captive breeding of *A. frenatus* was accomplished and the spawning had occurred between 0600 hrs to 1530 hrs, and in each spawning, 200 to 600 capsule shaped eggs of size 1.2 mm to 3.0 mm in length and 0.8 to 1 mm width were produced at a spawning duration of 15 to 30 days. The embryonic development was completed in 168 hrs after fertilization. Five batches of seeds were produced under captivity. The juveniles produced were used for development of broodstock. The hatchery produced juveniles had attained 60 to 70 mm after one year .

Captive breeding and seed production of *A. clarkii* were carried out. Two spawnings were obtained from one pair and juveniles were raised. Mass scale seed production was carried out.

Culture of copepod

Nauplius stage I

The calanoid copepod, *Pseudodiaptomus serricaudatus* was found suitable for culture. Different cell densities of three algal cultures (*Chlorella*, *Nannochloropsis* and *Isochrysis*) were tried. *Isochrysis* culture with a concentration 2.5-3 x10^5/ml was found ideal. Culture was maintained in beakers and good quality transparent plastic containers of 50 ml to 2 l capacity at room temperature. Mild aeration was necessary for higher densities. Fecundity ranged from 12-24eggs/female.

Sieves ranging from 50-500 µm were prepared for sorting the different stages. 250 µm was used to sieve adults and 100 µm was used to sieve naupliar stages. Five naupliar and 4 copepodite stages were observed. C5 moults turned into reproductive stages. Adults survived 30 days. Ovigerous females were observed from day 14 onwards. Predation by mature females was observed for all naupliar stages unlike other popular species of *Pseudodiaptomus* in culture. It is very much essential to filter out the adults everyday to maintain a continuous culture. Filtered naupliar stages for 5days can be reared together without any cannibalism.

The species is found hardy and showed comparatively good tolerance for salinity and temperature but the only negative point observed was its predation on naupliar stages.

Assessment of copepod as live feed for larviculture

A study was conducted to evaluate the feasibility of using copepod as a replacement of *Artemia* in the rearing of clown anemone fish *Amphiprion ocellaris* larvae.

The copepods of species *Oithona rigida* and *Euterpina acutifrons* were isolated from the collection and their cultures were maintained in 500 l tanks with gentle aeration under 35‰ salinity and pH 8.2. Water was completely replaced every week and the cultures were fed daily with the microalgae *Isochrysis galbana* (40000 cells/ml). Naupliar stages were separated from copepodites and adult stages using different sized mesh (300–100–45µm).

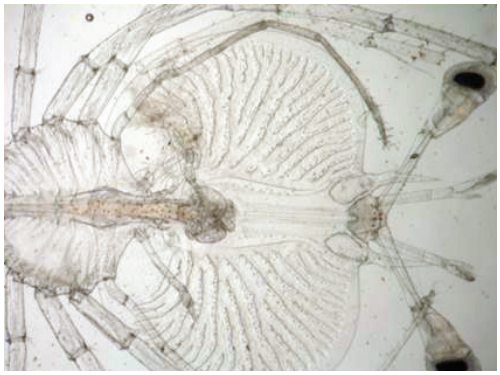
The newly hatched larvae of *A.ocellaris* were reared in 100 litre tanks at the rate of 2 numbers per litre and fed with rotifers at the rate of 10 nos. per ml. Five day old larvae which measured average size 4.01 mm were used for the experiment. The larvae were divided in two experimental groups (100Nos, in three replicates each) at the rate of 2 larvae per litre. Control group: fed rotifers (*Brachionus plicatilis*) (10 ind/ml) from day 5 to day 10 ph along with *Artemia* nauplii (6 ind/ml) from 5 dph to metamorphosis.

Treatment group: fed rotifers (10 ind/ml) from 5 to 10 dph, along with copepodites/copepods (6 ind/ml) introduced from day 5 ph to metamorphosis. It was shown that larvae fed a combined diet (rotifers/ copepod) showed better growth performance and showed significantly improved colouration.

Copepod Nauplius stage II

Lobster

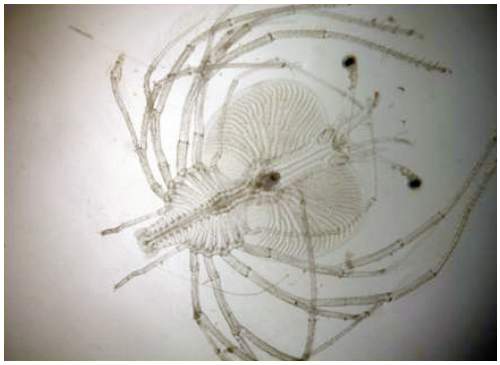
Trial run on larval rearing of the sand lobster *Thenus orientalis* was conducted in a dark, 5 m long raceway tank with 20 cm water and clam meat feeding. A temperature at 28°C and photoperiod of 12L: 12D were maintained. After the second stage due to *Vibrio* infection, the trial could not be continued.


Phyllosoma stage II

Sixteen trials on mass rearing of sand lobster larvae in raceway systems were conducted in the 400- 800 l capacity raceways at Kovalam Field Laboratory with 2- 4 per litre stocking densities and varying feeding schedules. Four trials were at 25°C, four at 26°C and four at 27°C. Four trials were run exclusively in static algal water and three in running algal water. Eight trials were with eight-hourly feeding schedule and eight were with twelve-hourly feeding schedule. *Vibrio* infection has remained the major limiting factor. However, one cycle using clear water with 4-day *Nanochloropsis* enriched clam meat had reached up to the PIV stage. In the raceway system, 70% survival at PII stage has been standardized, in spite of the incidence of *Vibrio* infection. In some batches, however, there is more than 40% attrition at the first stage itself and progression of stages was thus hindered.

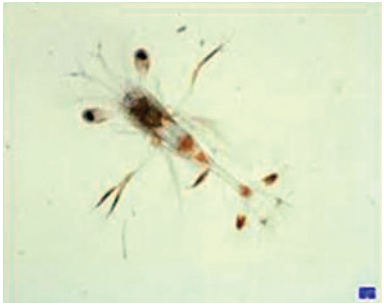
PII conversion had been found to be the maximum on day 6 with 6 hourly feeding and on day 7 with 8 hourly feeding and days 8-9 with 12 hourly feeding.

Trial runs on larval rearing of *P. ornatus* were carried out using white trays with running water. Sterilized *Artemia nauplii* (400 ppm) hatched at 25°C was used as feed. Early stage larvae were fed with freshly hatched

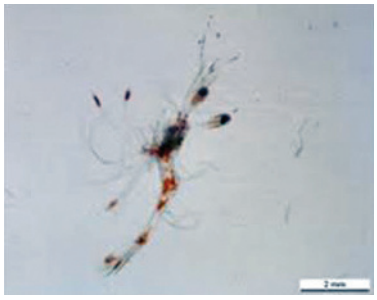

Phyllosoma stage III

Phyllosoma stage IV

Metamorphosed *L. amboinensis*



L. amboinensis 7 days after metamorphosis



23 days old juvenile of *L. amboinensis*

Artemia nauplii and later stages with 3 day old *Artemia nauplii* fed on *Nanochloropsis*. Stage V phyllosoma were observed in 26-30 days of rearing. The second trial run had to be discontinued after 7 days due to *Vibrio* infection.

Trial run on larval rearing of *P. rugosus* was carried out at low densities in a Kriesel rearing system using sterilized artemia. Feeding was carried out twice a day. Larvae showed improved survival rate and reached V phyllosoma stage. A new larval rearing chamber with 'U' shaped bottom, upwelling water and continuous flow and exchange has been designed for the spiny lobster larvae.

Ornamental shrimp

Adult specimen of cleaner shrimp *Lysmata amboinensis* was collected from the local aquarium shops and reared in hatchery. In the hatchery the shrimps laid eggs and larval rearing was attempted. Hatching took place after 10-14 days of egg lying. Eggs were attached to the pleopods. During early days of development, the eggs were green in color and turned grey as the embryos developed. The hatching time can be predicted by observing the eggs which will be dark in color and individual eggs are visible easily. On the day of hatching the shrimp was transferred to hatching/rearing tank in the evening. The eggs hatched out during night hours and the day one larvae had sessile eyes. Next day (after first moult) the eyes became stalked.

There was no naupliar stage for this shrimp and eggs hatched out directly to zoea. Larval rearing experiments were done using various feed combinations. In the first experiment, freshly hatched *Artemia* nauplii was fed along with *Nanochloropsis*. In another experiment, rotifer was given as initial feed followed by *Artemia.* Initial feeding with rotifers gave better survival and growth than *Artemia* alone. Feeding with copepods collected from wild was also tried, in the present study and no difference in growth and survival was observed. On two occasions where rotifers and *Artemia* were given as feed, the larvae had survived upto 36 days. The pleopod buds appeared, but larvae failed to moult further resulting in mortality. Survival from eggs upto 36 days was less than 5%.

Pearl oyster

Regular spawning and seed production programme on pearl oyster *Pinctada fucata* was continued during the period and spawning occurred almost throughout the year.

Successful larval development was observed during July to February of the year. A correlation could be derived for the peak and minor spawning season of the oysters.

Under conventional method, a total of about 2,00,000 spats of above 5 mm were produced in the hatchery and used for different purpose.

Ciliate infestation was more during May – June 2010 period. Attempts for control/elimination of ciliate by treating the larvae with Chloremphenical proved successful in some attempts. The dosage attempted was 75mg/l at a larval exposure time of 15 minutes.

During March and May 2010, heavy infestation of copepods in the rearing medium was observed, which also had negative impact on the success of the spat settlement.

Blacklip pearl oyster spat production in hatchery

Spat production was continued in the Blacklip pearl oyster hatchery at Port Blair. Improvements were made in the protocols and the final spat production percentage was improved from less than 1% to more than 5%. The fertilization rate which was initially 55% was improved to 85% by the end of 2010.

Details of the larval production of blacklip pearl oyster in the hatchery

Trials	No of eggs (nos/ml)	Fertilization rate (%)	Larval density (nos/1 ml)	Total Larvae (nos)	Total Spat (nos)	Total Juvenile %
1	6284	55	3456	13,824,000	13,580	0.15
2	3165	80	2532	15,192,000	120,000	0.21
3	2442	65	1587	3,174,000	50,600	0.26
4	4188	85	3560	24,920,000	102,000	45.0

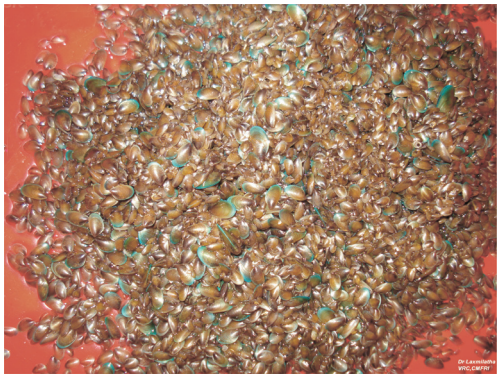
Many spat settlement materials have been tried and the shade-net made into a frilled garland was found to be the most effective in larval tanks. Training on hatchery protocols was organized for Islanders during February 2011. Officials from the A&N Island Fisheries Department, Forest Department, Pondicherry University and Zoological Survey of India attended the training. All aspects of blacklip pearl oyster broodstock development, spawning and larval rearing were covered in theory and in practice.

Edible oyster

A total of 30 lakhs advanced larvae (late umbo) were produced during October-November 2010 at Tuticorin.

Green mussel

Broodstock of green mussels were collected from the Kakinada Fishing Harbour. Spawning of the green mussel *P. viridis* occurred on 27th September 2010. Over 2 million larvae were reared in the hatchery. The 'D' stage larvae were obtained within 24 hrs. Feeding was initiated with microalgae *Isochrysis galbana*. Umbo stage was reached on day 8. The eyespot stage was reached on day 16. Pediveliger stage was attained on day 19. Spat settlement began on day 21 and continued up to day 30. The spat are being fed with *Isochrysis galbana* and *Chaetoceros calcitrans*. About 3 x 10^5 spat had settled and were reared in the hatchery. The spat attained an average total length of 1.5 mm (DVM) in 75 days of rearing in the hatchery. It was then transferred to the Bhimili Estuary in netlon cages to test the feasibility of transferring the spat at an earlier stage.



Spat of green mussel *Perna viridis*

Spat production of the green mussel in the hatchery has been standardised. Further trials will be carried out to develop a low cost method for large scale spat production of the green mussel.

GROW-OUT TECHNOLOGIES

Finfish cage farming

Seabass *Lates calcarifer*

During 2010-11, two 6 m diameter HDPE cages introduced in the Karwar Bay with 2500 and 6200 numbers of seabass seed were harvested and yielded 2 and 4 tonnes of fish respectively. The crop duration was only for 4.5 months. The FCR obtained was 1:3. The maximum weight obtained was 1150 g with a production of 25 kg m^{-3}. The feeding protocol developed at Karwar for seabass includes demand feeding, domestication of the stock to take the feed in a better way right from nursery rearing to farm, frequent net changing for better water exchange, development of better disease management protocols and twice a day monitoring of the stock.

Seabass harvest inauguration at Karwar by Fisheries Minister, Karnataka

Demonstration trial on open sea cage culture of the Asian sea bass in Chemmencherry Village (Kovalam Panchayat) concluded successfully on 3rd August 2010 with bumper harvest of 3.5 t of sea bass (six months of rearing in open sea cage). The cage successfully withstood rough sea conditions, including the devastating cyclone *Laila* of May 2010.

Harvested seabass

The weight range of harvested fishes were 0.8 - 1.8 kg (25-49 cm TL) with an average weight of 1.3 kg. More than 90% of the fishes were in the weight range of 1.1 to 1.5 kg. Harvested fishes were sold at prices ranging from Rs.180/- to Rs. 200/- per kg. Sale proceeds, amounting to Rs. 5,02,000/- was handed over to fishermen of Chemmencherry by Dr. P. Krishnaiah, Chief Executive, NFDB at a function held in the Madras RC of CMFRI, Chennai.

Seabass harvest at Chennai

Seabass nursery at Cherai, Kerala

Cage culture experiment was conducted at Moothakunnam backwaters, about 1 km away from Munambam barmouth, in Kerala, for a period of six months. Seabass fry, measuring an average 2-4 cm brought from the RGCA hatchery, were reared for a periodof 45 days in a private fish pond in 2 m x 2 m x 1.5 m HDPE hapa.

About 3,500 numbers of juvenile fish (15-25 g) were transported and stocked in a 6 m dia HDPE cage installed at 7 m deep open backwater

system at Moothakunnam. The fish were fed *ad libitum* thrice a day with chopped low cost fish (sardine, *Stolephorus, Ambassis* etc.) procured from local harbour and markets for a period of six months. After six months, the fish were harvested at a size ranging from 800 to 1440 g. Total production of one tonne was obtained which was locally marketed.

Seabass seeds, *Lates calcarifer* (45 - 50 mm) brought from RGCA were initially reared in cement and FRP tanks. From this batch, 2,900 numbers of seeds (76 - 138 mm) were transferred to a sea cage of 6 m diameter, installed in the Gulf of Mannar. Another sea cage was also stocked with 2,437 nos. of sea bass seeds one month later.

Harvested seabass

The fingerlings weere fed with fresh sardine @5% of the biomass. The average initial length of the fingerlings was 104.8 mm and the average initial weight 14.1 g. Mortality of seabass was observed due to suspected *Vibrio* infection. In spite of oral administration of oxytetracycline through feed and relocation of the cages to a deeper area, mass mortality continued up to July 2010. The average length of 28 mm and average weight of 322 g were recorded during the sampling carried out on 21st May 2010.

During the sampling on 27th September 2010, the length recorded ranged from 33 – 43 cm and the weight ranged from 500-1000 g. The modal length was 36 cm and average weight was 721.33 g.


Harvesting seabass in the sea

The harvest of seabass was conducted on 20th October 2010 in the presence of officials from DHAN Foundation and M.S. Swaminathan Research Foundation along with the representatives of Self Help Groups supported by them. The nursery reared fingerlings of seabass were stocked in two sea cages during February 2010. The average initial length and weight were 10 cm and 14 g respectively. The length and weight of the fish harvested ranged from 36 to 50 cm and from 500 to 1500 g, respectively. The modal length was 41 cm and the average weight of the harvested fish was 800 g.

Grey mullet *Mugil cephalus*

Mugil cephalus fry collected from the wild (2-4 cm) were nursery reared in KVK and private ponds in HDPE hapas (2m x 2m x 1.5m) till they reached 10 to 15 cm fingerlings. About 3000 numbers of fingerlings were stocked in the cage moored in open backwater. Fixed mooring system using anchors fixed in the river bed was followed. Outer safety net, inner growout net and bird nets were used. The fish were fed thrice a day with wet scampi grow-out feed mixed in equal proportion with wheat bran. Mullet had the advantage of grazing on the algal mat attached to the net which resulted in minimum fouling of the net. After a period of six months, batch harvesting was done for efficient marketing of the fish. About 750 kg fish ranging in size from 250 to 450 g, were harvested and were sold to the local markets @Rs.200- 210/ kg.


Harvested *M. cephalus*

Pearlspot *Etroplus suratensis*

About 2000 numbers of pearl spot *Etroplus suratensis* (5-10 cm) were stocked as an additional stock along with *M. cephalus* after two months of stocking. During harvest *i.e.,* after four months of stocking, about 225 kg was harvested from the cage.

Harvested *L. argentimaculatus*

Red snapper *Lutjanus argentimaculatus*

Growth of *Lutjanus argentimaculatus* stocked in cages at Uppunda, Byndoor was monitored The stocking density was about 300 numbers and the average daily growth registered during the rearing period was about 3.1 g.

Harvest was carried out during August - September 2010. The weight range of harvested fishes were 1.1 - 1.5 kg, with a survival of 60% and total production of 220 kg.

Cobia *Rachycentron canadum*

Cage farming of cobia *Rachycentron canadum* was experimented for the first time in India in the Gulf of Mannar from the hatchery produced fingerlings. The fingerlings were stocked after nursery rearing in grow out cages in May 2010. The length range of fingerlings stocked was from 22- 26 cm and weight ranged from 35-70 g. The fish were fed with trash fish *ad libitum* once in a day. At the end of January 2011 (after 7 months of stocking in grow out cages), the length range of the fish was 60-70 cm and weight range 2.8 to 3.5 kg. Grow-out is being continued. The results show that cobia is a lucrative species for cage farming in India.

Sample of cobia from grow-out cage

Shellfish

Spiny lobsters

Lobster seeds purchased from Chinnamuttam, Kadiapatnam, Mullur and Vizhinjam areas were stocked in two circular HDPE cages near Chinnamuttam area, Kanyakumari. A total of 1,240 lobsters of average size 73 g were stocked during first week of August in one cage and 1,150 numbers with average size 80.2 g were stocked in second cage during September. The first cage was harvested on 8th December 2010. Average size was 190.2 g with a survival of 72.5%. 172 kg lobsters were harvested from the first cage. The second cage was harvested on 27th December and the average size was 178.5g with a survival of 69%. About 130 kg of lobsters were harvested.

About 2000 lobster seeds were stocked in February 2010 in cages at Kanyakumari. After 4 months, growth was found to be >0.74 g day^{-1} with 80 % survival at final sampling. 200 kg seed material grew to approximately 306 kg during this period.

Harvested lobsters

Molluscs

Growth and production of hatchery produced clam *Paphia malabarica* was attempted in the Karapad Bay. About 2000 hatchery produced clam seeds of 4.3 mm (av.size) were transplanted in the velon net made pen of 3 x 3 m size.The transplanted clams survived well and the growth and survival was monitored for 10 months. The clams showed a growth rate of 3.0 mm/month and reached an average size of 28.0 mm/5.5g.

Pearl production in *Pinctada fucata*:

Nucleation of 225 pearl oysters were carried out at the shellfish hatchery at Visakhapatnam during the period. They were maintained in the onshore rearing system for pearl production. The pearls were harvested on 21-06-2010 after a period of 8 months. 36 pearls were harvested out of which 25% were good quality pearls with good coating of nacre.

Stock oysters for image pearl production studies

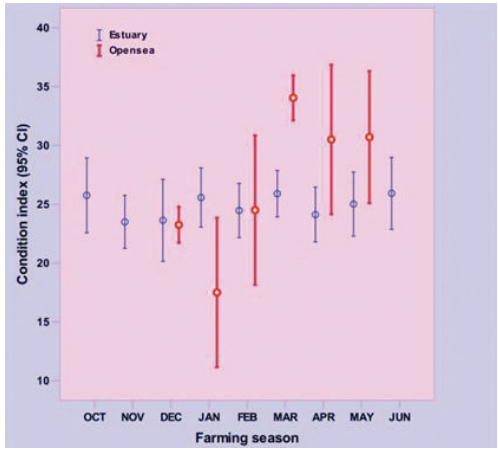
Divers were engaged to collect pearl oysters from Vizhinjam Bay and nearby areas. The collected oysters included *Pinctada fucata, P. sugillata* and *P. margaritifera*. The dominant species was *P. fucata*. 1000 oysters of *P. fucata* and 750 numbers of *P. sugillata* were stocked. The oysters were stocked in rectangular cages fabricated for the purpose. The stocking density ranged from 75 to 200 numbers per cage depending on the size of the oysters. About 100 image nuclei were made and kept ready for implantation.

Oysters stocked in cages

Growth rate and condition index in green mussel in different farming areas

The growth rates and condition index of green mussel *Perna viridis* farmed in different estuarine and open sea locations from 1996 to 2010 was analysed. The condition index of mussels ranged from 17.5 in January to 34.0 in March in the open sea farming systems (av. 27.91±6.02).

In estuarine farms the mean condition index was lower (24.9±3.02) varying from 23.5 in November to 25.9 in March and June. Condition index showed significant difference in the two farming environments ($p<0.05$). The growth rate in estuarine racks varied between 5.0 and 10.9 mm month^{-1} in different farming areas/ year. The open sea presented less variation in the growth rate ranging from 7.4 to 8.8 mm month^{-1}.



Average condition index of green mussel in estuarine and open sea farming areas

Mussel farming through participatory programme

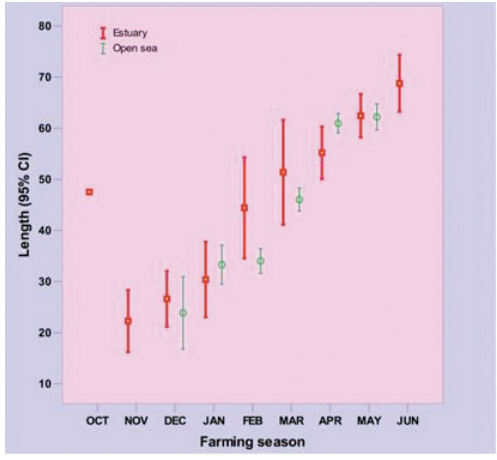
Mussel farming practice in estuarine waters was adopted by 13 shrimp farmers in 2009-10 as a group farming activity in Sita Estuary. About 5,400 kg of shell-on mussels were harvested from six estuarine farms. Initially, 5,000 kg of shell-on mussels was harvested by March 2010 from five racks. The larger mussels (~30 count shell-on/ kg) were segregated and marketed in Goa. The farm gate value for the harvest was Rs. 1.15 - 1.25/ shell-on mussel initially, later by June 2010 the value reached Rs. 2/ shell-on mussel.

Four racks were fabricated at Sita and Swarna estuaries near Saligrama by fishermen groups. Coir ropes of 0.75-2.5 m length were seeded in batches with green mussel, *Perna viridis*. Seeding was carried out from last week of December 2010.

Farming of high value shellfishes

The number of villagers involved in farming increased and the farmed oyster production increased from 1500 t in 2009 to 2800 tonnes in 2010. In 2010-11 season, the production units have increased and 350 more villagers have become involved. The first seed production oyster hatchery and training centre along the Indian west coast was developed. 75,000 oyster spat were produced and a remote setting unit i.e., a seed production unit in a village about 25 km from the hatchery and near to farms was developed.

A depuration unit with a capacity of 3000 oysters per run was developed in a village. The unit operated by farmers has been supplying depurated oysters to high end restaurants in Kochi City @ 500 oysters per week since November 2010. (New value chain and new product). An automated steam producing and heat shucking unit was designed, fabricated and tested. The unit can heat shuck 100 oysters per 6 minutes using steam. This unit will reduce physical drudgery faced by women



Average growth rates (mm) of green mussel in estuarine and open sea farming areas

Mussel rack near Saligrama

farmers during post harvest processing and also assure grit free high quality oysters. (New technological development; solution for one of the major problems faced by oyster farmers).

An oyster depuration display unit was designed, fabricated and has been utilized by one of the major high end restaurants in Kerala which has enhanced consumer confidence and has been able to support international tourists. This has helped the farmers to get Rs 5 per oyster. (New technological development, new value chain and increased profit for farmers).

Lobster broodstock rearing systems

High density broodstock rearing facility designed with 100 SL m^2 in with temperature, salinity, pH and photoperiod control. A website www.oysterandlobster.naip.org.in was created to promote oyster as well as lobster culture.

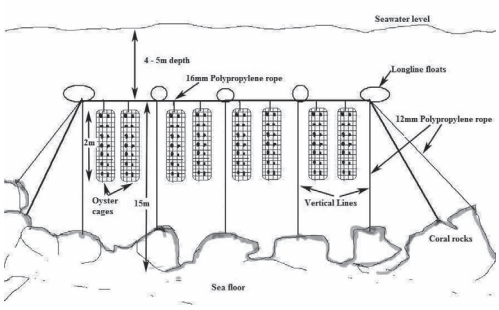
ANPOREP – Pearl oyster restoration programme

Since natural population of blacklip oysters are very scarce in the Andaman & Nicobar Islands, a programme to re-populate oyster beds of the islands was taken up with the involvement of secondary school students of the Government Higher Secondary School in Burma Nullah near Port Blair. The Department of Education of A&N Island Administration has given support to the programme and secondary school science clubs are being involved. The hatchery produced spats are settled on to natural rocks which are then placed on a heavy concrete platform with a metal mesh cover to protect spats from predators and heavy wave action. The ANPOREP platforms are placed in subtidal areas protected from waves by the school children and they take care of the structure and pearl oysters by cleaning and maintaining it every two weeks.

The automated heat shucking unit

Pearl farming method - the Polynesian system

Pearl seeding was undertaken by the Polynesian expert. The main difference in the method used in fucata oysters are – no anesthetic is used to relax and open oysters, instruments used are larger in size and nuclei used are biocoated with an antibiotic. The nuclei size used was 2.6 BU (~7 mm) and only limited number of oysters could be seeded due to the spent condition of the oyster gonads. A few mabe oysters *Pteria penguin* were also seeded with round nuclei on a trial basis. Post-operative nucleus rejection was very low in *Pinctada margaritifera* and high in *P. penguin*. The seeded oysters were then hinge notch drilled and hung from chaplets in an undersea longline system. Convalescence was provided to seeded oysters by placing the chaplets in well aerated tanks for a week before transferring to the farm.



Polynesian system of growing pearl oysters in an undersea location

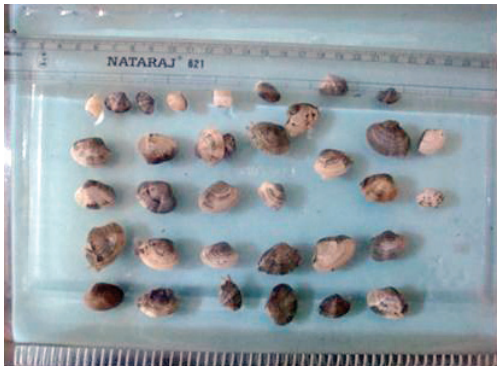
Based on the consultation provided by the Polynesian expert, the pearl culture system was changed from raft and cage farming system to an undersea longline system with oysters hung on chaplets which are protected by large mesh PVC fencing nets or PVC coated metal meshes. A pictorial representation of the pearl farm following the new system is shown. The farm is totally invisible from above the water, and accessible only through SCUBA or skin diving. The raft is now used only as a cleaning station. Un-implanted oysters are kept at the rate of 2 per knot, while only one implanted oysters is placed on a knot. Spats are hung by drilling the ear rather than the hinge notch.

Polynesian system involving growing pearl oysters in an undersea longline with oysters kept in chaplets enclosed in rigid mesh baskets was adopted at Port Blair blacklip pearl oyster farm.

Clam farming trials

Trials on different on-bottom and off-bottom shallow water culture methods for *Paphia malabarica* and *Villorita cyprinoides* were done in Ashtamudi Lake and Vembanad Lake respectively. The farming trials had duration of about 6-7 months.

Black clam: Different on-bottom and off- bottom methods such as cage, pen and bag culture were tried with different stocking densities. Among the preliminary treatments, on-bottom pen culture with a stocking density of 500/m^2 gave the best results for black clam in terms of growth and survival. The water quality parameters of the farming sites, biometric and biological studies of the farmed clams were carried out periodically during the culture period.



Farm grown clam from hatchery produced seed

Short-neck clam: As done in the case of black clam, on- bottom culture methods such as cage, pen and bag culture were carried for short neck clam also. The trials had varying stocking densities. Among the treatments, on bottom pen culture system with a stocking density of 1000/m^2 was found to give most promising results for the species. Monthly analyses of different water quality parameters of the farming sites and biometric and biological studies of the farmed clam were also carried out simultaneously at regular intervals. Based on the results of initial trials, confirmatory farm trials to identify maximum stocking density that could yield maximum economic results for both the clam species are being carried out.

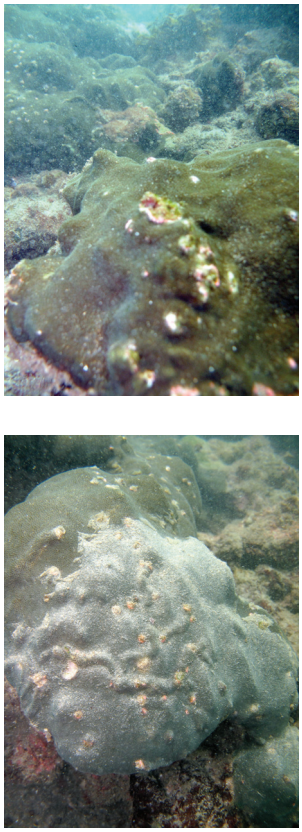
Integrated farming

Experiments on integrating seaweed in shrimp farming pond was carried out by stocking shrimps in two different ponds of 0.1 h size. One pond was kept as control with shrimp alone and in the other pond seaweed *Enteromorpha intestinalis* was also introduced along with shrimp. The significant achievement of this experiment is the control of blue green algal bloom in experimental pond because of *Enteromorpha* growth. Prawn harvest in the treatment pond was better and hence adopted by farmers.

MARINE BIODIVERSITY

Corals

Underwater surveys conducted during 2011 following Line Intercept Transect Method in Vizhinjam-Thankassery waters to assess the present status of corals revealed the existence of patchy coral reefs as in previous surveys. The reefs spread around Thankassery Harbour area in Quilon were found to be dominated by *Pocillopora damicornis* and *P.verrucosa* belonging to the family Pocilloporidae. Occasional incidence of bleached *P. damicornis* among algal settlement and sedimentation was recorded in this area. However, at Thirumullavaram (Quilon), only massive corals were present, predominantly *Porites lutea*. Most of the massive corals in this area were covered with algae/seaweeds and sediments and therefore were dead or affected by disease.



Pink line syndrome in *Porites lutea* from Thirumullavaram, Quilon

A similar comprehensive survey was conducted at Vizhinjam Bay to assess the reef condition which is fundamental to coral reef monitoring. The live coral coverage was measured using Line Intercept Transect Method at fixed sites in the reefs of the bay and compared with the surveys conducted during 2008. Substantial growth in live coral colonies was observed over the two years. From samples of ulcerative white spot syndrome affected corals (*Porites* sp.) collected from Vizhinjam Bay, unique pink translucent bacterial colonies were isolated. These organisms were found to be slow growing gram negative rods. The strains were identified as *Sphingomonas* sp. Another strain (C144) isolated from *Pocillopora* sp. growing as orange red colonies (gram positive cocci) on Nutrient agar plates (with 2.5% NaCl), was identified as *Microbacterium arborescens*. *Vibrio* spp. were the predominant colonies isolated from bleached *Pocillopora* sp. Preliminary studies were made to assess the suitability of various substrates for undertaking growth studies on corals in Vizhinjam Bay using *Pocillopora* spp. Based on the results, experiments have been initiated for coral growth studies on *Pocillopora verrucosa* using cement coated bricks and acrylic sheets as substrates.

Taxonomic profile of a soft coral species, *Cladiella australis* (Mactadyen, 1936) (Colt coral small, blushing coral, blanching soft coral) which is a new distributional record for the Palk Bay reef ecosystem has been studied. Collections were made from the shallow reef area, at 3-5 m depth, off Villundy in the Palk Bay by Scuba diving. Earlier report shows that in India the species is confined to Little Andamans. The sclerites of this species have smaller dumbbells when compared to those in the temperate waters. Polyps are without sclerites. Sclerites are present in the vicinity of the polyps. Three more species of soft corals were collected from the Palk Bay and identified through chemically extracted sclerites and measurements made from the photomicrographs. They were *Dampia pocilloporaeformis*, Alderslade, 1983, *Lobophytum*

pauciflorum (Ehrenberg,1834) (Devil's hand coral) and *L. crassum* von Marenzeller,1886 (Cabbage leather coral).

Lobophytum pauciflorum was acclimatized to the hatchery conditions in the hatchery at Headquarters. An experiment on feeding trial was set up on 03.12.2010 using soft coral explants. *Nannochloropsis* sp. and an artificial feed were chosen as feeds, and each set along with control were run in triplicate. The soft coral explants were found to attach firmly to the substratum after 20 days of cutting and on 28th December, new polyps were clearly visible on the cut portion of the coral explants. The work is in progress.

Cladiella australis

Parent stock of some species of soft corals was cultured in the wet laboratory at Mandapam Research Centre for further propagation experiments. Attachment studies on *Lobophytum* sp. indicated effective attachment on tiles in a span of 20 days. Propagation studies on *Sinularia* sp. using terminal fingers also resulted in successful establishment of explants (28.5%), with the parent showing 100% recovery.

Sponges

Sclerites were extracted using chemical treatment from six different parts of the samples of sponges collected off Enayam-Vizhinjam. Sclerites were studied and measurements taken to record the taxonomic status and species-wise distribution of sponges in the habitat. Identification of 14 species has been completed. The present study revealed that Enayam-Vizhinjam area has a good coral/sponge cover with high fish density.

Lobophytum pauciflorum

Field surveys were carried out and intertidal collections were made from Palk Bay for understanding the distribution and availability of sponge resources and the threats they face. Sponge-rich intertidal regions were observed in Shangumal, Thonithurai, Koilvadi, Thiruppalaikudi and Devipattinam.

Quadrat sampling conducted in the intertidal region at Shangumal revealed a distinct zonation of different types of sponges; the dominant sponge was *Spirastrella* sp. Bottom set gill nets operated in some places along the Palk Bay were found to cause destruction to the sponges. The mini trawls operated at Devipattinam and Thiruppalaikudi were also found to cause extensive damage to the sponge resources. At Shangumal, although the area was polluted, a good population of sponges, predominated by *Spirastrella* sp. existed. Underwater surveys conducted at Adimalathura also indicated the presence of diverse types of sponges.

Coral explant (Initial)

Reef fish

Fish assemblages and sponges associated with patchy coral reefs around Muttom and Ennayam in Tamil Nadu and Adimalathura to Marathody in Kerala were investigated by using visual census method. Vizhinjam and Varkala recorded high species diversity. A total of 36 species belonging to 26 families were recorded along the transects. Fishes of Pomacentridae family dominated in all the major reefs followed by Siganidae. Most pomacentrid species are strongly site-attached and have only small territories or home ranges. Coral reef fishes from traps in and around Vizhinjam waters were dominated by species belonging to the families Chaetodontidae and Siganidae.

Coral explant showing growth

Coral reef fishes landed from the Gulf of Mannar at Pamban, Therkuvady, Mandapam and Keelakarai were monitored and both qualitative and quantitative studies were made. A total of 183 species belonging to 51 families were recorded. Out of this, two species namely, *Rhinopias eschmeyeri* and *Ablabys binotatus* are new distributional records to Indian waters. The trawl landings constituted the maximum number with 144 species whereas hooks &lines recorded the least number with 29 species. A total of 202 species of coral reef fishes belonging to 114 genera were collected, identified and database prepared from off Tuticorin during the period 2008-2010. Out of this, 30% contributed to ornamental fishery. High species diversity was observed in the families of Labridae (24) and Chaetodontidae (17).

Around 304 species under 45 families of fishes were recorded from hooks and lines, gill nets and trawlers operated off Kerala, Tamil Nadu and Karnataka coasts. A rapid survey was conducted to assess the species diversity and abundance of reef fishes at 14 sites in Andaman Islands for a period of two months. A total of 101 species of fish belonging to 65 genera under 37 families were recorded. Hooks & lines and *tharni jal* (flowing gill net) were the two major gears used by local fishermen. Families with maximum species were Serranidae and Lutjanidae. Species richness was found to be the highest at Wandoor and Jungligut.

Other resources

Rhinopias eschmeyeri

Fifty species of brachyuran crabs, 3 species of Porcellanid crabs and 4 species of Hermit crabs were collected, identified and database prepared from the Gulf of Mannar. Two new species of brachyuran crabs and two species which are new distributional records to Indian waters have also been collected from the Gulf of Mannar and identified.

Wide fluctuation was noticed in the numerical density and biomass of holothurians at the study area north of Tuticorin Port. The numerical density varied between 0.21 and 1.43 with a mean of 0.6 $\pm$0.13 no m^2 and biomass varied from 12.9 to 161.7 with a mean of 64.5$\pm$ 16.6 g m^2. Maximum numerical density and biomass were observed during September. Adults constituted 100% of the population during June and 45.5 to 78.3% during the rest of the period. Sea urchins were collected from Panambur area and from the exploratory fishing operations along the Mangalore coast. *Stomopneustes variolaris* (Lamarck, 1816) and *Temnopleurus toreumaticus* (Leske, 1778) were found to be widely distributed. Scyphomedusae collection was done in Mulki Estuary and the species *Lychnorhiza malayanus* Stiasny 1920, was documented. This species is being recorded for the first time along the coast of Karnataka. Twenty two species of marine finfishes have been documented for the first time in addition to the already documented 390 species at Mangalore Fisheries Harbour.

Ablabys binotatus

Species variation and biodiversity of the fishes of the family Lutjanidae

A total of 43 species of fishes of the family Lutjanidae were identified and taxonomic and biodiversity details were collected. Of the 43 species, 60% belonged to genus *Lutjnaus,* 8% to *Pristipomoides,* 5% each to *Aphares* and *Etelis* and the rest to the genera *Aprion, Lipocheilus, Pinjalo*, *Pterocaesio*, *Macolor* etc. (22%). *Paracaesio sordida* is a new

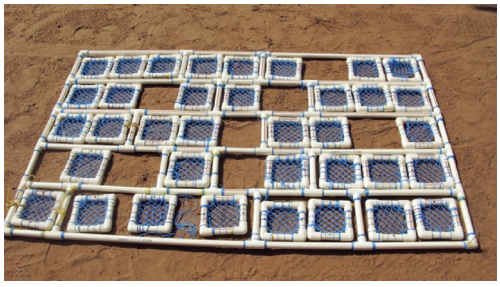
distributional record to the north-west coast of India. About 80 % of the species are commercially important forming fishery along the coast. Maximum number of species was recorded from Cochin (22 species) followed by Mandapam (17), Vizhinjam (11), Veraval (10) and Visakhapatnam (6).

Detailed information on the morphometric and meristic characteristics, biodiversity, nomenclature, taxonomic description and biological characteristics of all the 43 species were collected. A four-day workshop was held on "Taxonomy and Biodiversity of the fishes of the family Lutjanidae" during 8-11 February, 2011 for consolidation of the data collected, species verification and data analysis. A publication on the "Lutjanids of India" is under preparation.

Paracaesio sordida

Biodiversity and ecological changes in sea cage farming area

At Kanyakumari, the cage site had comparatively low concentration of benthic organisms compared to the reference site. The fauna in the cage site comprised mainly of polychaetes, bivalves and filamentous algae. In the reference site, amphipods formed the dominant component among macrobenthos. Copepods were also recorded from this centre, but in very meagre numbers. Twenty two genera of phytoplankters were recorded from the study sites comprising both the cage and reference sites. Overall, the density of phytoplankton was higher at the cage site before and during the experiment. However, diversity of phytoplankters was more distinct at the reference site. At Kanyakumari, a total of eleven groups of zooplankters were recorded from the study area, *i.e.*, from the cage and reference sites together. The copepod density was higher at both the sites in August followed by higher density of *Lucifer* and cladocerans in September. Overall, there was not much variation in zooplankton composition among the two sites. A rich assemblage of fishes was observed around the cages. Large schools of siganids and pomacentrids were also recorded during the survey.



Experimental panels (made of PVC Pipes)

Wooden framed panels 1m x1m suspended every month from open sea floating cages revealed a sequence in fouling. In July, the dominant species attached was mussel spat; in August it was dominated by miscellaneous species. From September onwards algae started appearing and by November- December the algae completely took over domination. It was also observed that the season of installation of the cage has significant impact on the ultimate dominance of the fouling species. The succession of foulers in this area was in the order of oysters-barnacles- mussels- algae. A net exchange is essential mainly during fouling by barnacles and mussels. This means that if we go for a net exchange during July, the same net can be continued upto 6 months or more. The main foulers after this will be small patches of mussels and algae. Mussel patches mostly get cleaned by cultured lobster themselves and algae by algae-eating fishes available in the area. Sponges and ascidians which are the common foulers of Vizhinjam area were rather rare in the fouling community of the Kanyakumari area.

Ascidian fouling on nets in Vizhinjam Bay

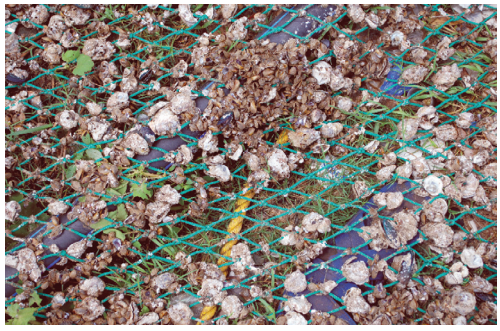
At Karwar, the water quality parameters fell within the ideal range. The average temperature, salinity, dissolved oxygen, primary production, pH and BOD were 29.91^{o}C , 26.18 ppt., 3.66 ml l^{-1}, 581.02 mgC m^{-3} day^{-1}, 6.73 and 1.68 mg l^{-1} at the surface water of cage site and those of reference site in the month of December 2010 were 29.0 ^{o}C , 33.80 ppt., 3.53 ml l^{-1},

Distribution pattern of Lutjanid species at different centres

Species/Centre	Common name	Veraval	Karwar	Mangalore	Cochin	Vizhinjam	Tuticorin	Mandapam	Visakha-patnam
Aphareus furca (Lacepède, 1801)	Smalltoothed job fish				+				
Aphareus rutilans Cuvier, 1830	Rusty job fish				+				
Aprion virescens Valenciennes, 1830	Green jobfish				+			+	
Etelis carbunculus Cuvier, 1828	Ruby snapper					+			
Etelis coruscans Valenciennes, 1862	Flame snapper				+				
Lipocheilus carnolabrum (Chan, 1970)	Tang's snapper				+				
Lutjanus argentimaculatus (Forsskal, 1775)	Mangrove red snapper	+	+	+	+		+		
Lutjanus bengalensis (Bloch, 1790)	Bengal snapper				+				
Lutjanus biguttatus (Valenciennes, 1830)	Twospot banded snapper					+			
Lutjanus bohar (Forsskål, 1775)	Twospot red snapper		+	+	+	+	+		
Lutjanus boutton (Lacepède, 1802)	Molluscan snapper				+				
Lutjanus coeruleolineatus (Rüppell, 1838)	Blue line snapper				+				
Lutjanus decussatus (Cuvier, 1828)	Checkered snapper					+	+	+	
*Lutjanus ehrenbergi*i (Peters, 1869)	Ehrenberg's snapper				+				
Lutjanus erythropterus Bloch, 1790	Crimson snapper					+			
Lutjanus fulviflamma (Forsskal, 1775)	Black spot snapper		+		+	+	+	+	
Lutjanus fulvus (Forster, 1801)	Black tail snapper				+		+	+	
Lutjanus gibbus (Forsskål, 1775)	Humpback red snapper				+				
Lutjanus guilcheri (Fourmanoir, 1828)	Yellowfin red snapper			+					
Lutjanus johnii (Bloch, 1792)	John's snapper	+	+	+	+		+		+
Lutjanus kasmira (Forsskål, 1775)	Blue and Yellow snapper			+	+		+		
Lutjanus lemniscatus (Valenciennes, 1828)	Yellow steaked Snapper	+		+	+		+		
Lutjanus lunulatus (Park, 1797)	Lunar tail snapper		+	+	+				+
Lutjanus lutjanus (Bloch, 1790)	Bigeye snapper	+			+	+		+	+
Lutjanus madras (Valenciennes, 1828)	Indian snapper		+		+		+	+	
Lutjanus malabaricus (Bloch & Schneider, 1801)	Malabar blood snapper								+
Lutjanus monostigma (Cuvier, 1828)	One spot snapper				+				
Lutjanus qiunquelineatus (Bloch, 1790)	Five lined snapper	+				+			
Lutjanus rivulatus (Cuvier, 1828)	Blubber lip snapper	+			+				+
Lutjanus rufolineatus (Valenciennes, 1830)	Yellow lined snapper				+				
Lutjanus russelli (Bleeker, 1849)	Russell's snapper		+	+	+	+	+	+	+
Lutjanus sanguineus (Cuvier, 1828)	Blood red snapper				+				
Lutjanus sebae (Cuvier, 1816)	Emperor red snapper							+	
Lutjanus vitta (Quoy and Gaimard, 1824)	Brown stripe snapper	+			+	+	+		
Macolor niger (Forsskål, 1775)	Black and white snapper				+				
Paracaesio sordida Abe and Shinohara, 1962	Dirty ordure snapper	+			+				
Pinjalo lewisi Randall, Allen and Anderson, 1987	Red pinjalo				+				
Pinjalo pinjalo (Bleeker, 1850)	*Pinjalo*	+	+	+	+	+	+	+	
Pristipomoides auricilla (Jordan, Evermann & Tanaka, 1927)	Goldflag job fish				+				
Pristipomoides filamentosus (Valenciennes, 1830)	Crimson job fish	+			+	+	+		
Prisripomoides multidens (Day, 1871)	Goldbanded job fish			+					
Pristipomoides typus Bleeker, 1852	Sharp tooth job fish				+			+	
Prisripomoides zonatus (Valenciennes, 1830)	Oblique banded snapper				+				

+ presence of lutjanid species

1200.64 mgC m^{-3} day^{-1}, 7.3 and 2.07 mg l^{-1}, respectively. Cage fouling was observed throughout the period at Karwar. The fouling communities comprised of edible oysters, pearl oysters, green mussels, barnacles and *Modiolus* sp. in all months. Safety measures were undertaken against fouling of cages and nets by cleaning the cages and changing the nets at regular intervals. Diversity of wild fish fauna as well as natural entrants to the cages at Karwar were studied and finfishes including *Therapon* sp., *Ambassis* sp., *Thryssa* sp., crabs like *Grapsus albolineatus,* spider crab, rock crab and sea urchin were recorded.



Fouling on the net

Water sample analysis for enumeration of bacterial load inside the cage and at reference point in Karwar during the period from January to December 2010 revealed the presence of *Staphylococcus* spp., *Vibrio* spp., and *Enterobacter* spp. The count ranged from 5.8 X 10^3 to 1.51 X 10^9 CFU/ml in cage waters and 1.4 X 10^3 to 3.5 X 10^9 CFU/ml in the reference site. Appearance of *Vibrio alginolyticus* during April-June 2010 was responsible for an outbreak of vibriosis in Asian seabass cultured in open sea floating cages.

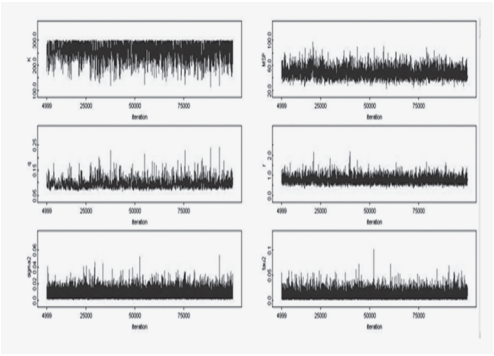
In open sea cages at Mandapam, the dominant fouling communities were the barnacles. In addition, pearl oysters, edible oysters and ascidians were also common. Other communities observed included sponges, seaweeds and bivalves including *Pinna* sp. and *Modiolus* sp. Attachment of pearl oyster spats on the nursery cage nets was observed during May 2010. The spats in large numbers (611 no./sq ft) were found attached on the nursery cage nets stocked with cobia fingerlings. The spat settlement took place in a span of just one month after installation of the cage.

Oysters attached to the net

The fouling studies in a beached cage net during May 2010 indicated the presence of large number of ascidians. The other fouling organisms were barnacles, rock oysters and pearl oysters. Seaweeds were also encountered on the cage nets. Crabs including *Charybdis* sp. and spider crabs were present. Spats of *Modiolus* sp. in large numbers were observed during November 2010.

The entrant fishes included the lion fish and banner fish. Besides, lobsters and shrimps (*Hippolysmata* sp.) were also noticed. The crabs observed in the cage nets included the depressed red rock crab *Plagusia tuberculata*, hairy crab *Pilumnus rouxi,* spider crab *Hyastenus diacanthus*, Porcellenid crabs (3 species) and some visiting Portunids. Microbial studies indicated that the microbial load was below detectable limit in both seawater and sediment samples.

Fisheries and Ecosystem Modeling

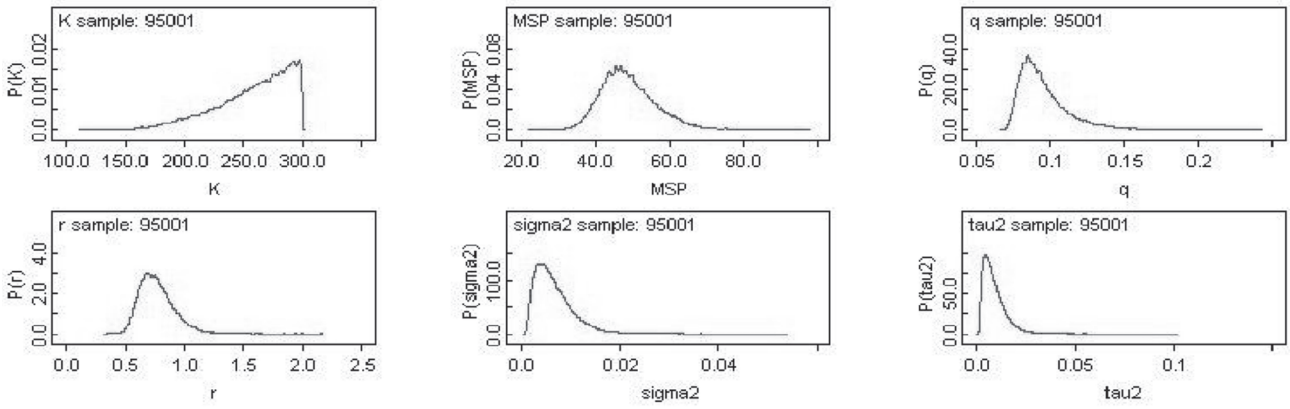


History of Markov Chain Monte Carlo (MCMC) simulations carried out for Bayesian estimation of posterior probability densities of non-linear Schaefer model parameters for the fishery in Tamil Nadu

Decision support systems for management

Towards estimating the posterior probabilities for the pre-decided biological reference points viz., Maximum Sustainable Yield (MSY) and the corresponding fishing mortalities (F), two established Bayesian estimation algorithms were shortlisted viz., MCMC with Gibbs sampling and Rejection Sampling algorithm. Decision matrix for providing final inference to the prospective stock analyst/ fishery manager has also been outlined suiting to Indian marine fisheries. The OpenBugs software, a Markov Chain Monte Carlo (MCMC) based Bayesian analysis tool, was used to study the state-space models on various fisheries of India.

OpenBugs codes for non-linear Schaefer model were developed and 15 year catch and effort time series data sets of Kerala, Karnataka, Tamil Nadu and West Bengal were analyzed using OpenBugs with 10000 updates each. Bayesian estimates of posterior probability densities of Schaefer model parameters and MSY were obtained for these maritime states. Towards consolidating the GUI modules developed on the deterministic stock assessments methods like VBGF fitting the Visual Basic application developed has been tested and finalized.



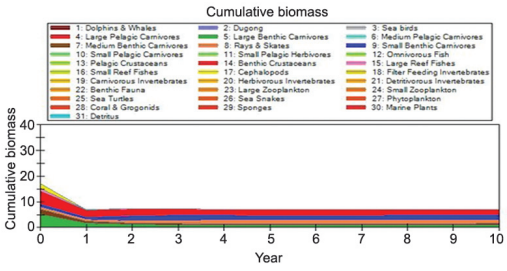
Estimated posterior densities of parameters of non-linear Schaefer model and Maximum Sustainable Production (MSP) for Tamil Nadu

Sustainability profiling of Kerala fisheries

The sustainability profiling of Kerala fisheries, which has been planned to be based on primary as well as secondary data has been pursued by the conduct of the second round of survey involving more than 500 stake holders who are both fisher folk as well as fish marketing

people. Expert level survey plan has been finalised. The electronic database has been populated with the results of the first round of survey wherein 100 stakeholders have been surveyed. Parallel collation of relevant data on techno-biological, sociological, economic, ethical and ecological indicators of the three major regions of Kerala fisheries has been completed.

The preliminary analysis of data indicated the near uniformity on the techno-biological facets of sustainability amongst major landing centres of the state whereas the picture was quite variegated on the counts of socio- ecological bench marks. The final analytical procedure based on Euclidean distance based Multi Dimensional Scaling has been finalized with the SAS 9.2 software as the background medium of analysis and ALSCAL as the algorithm.



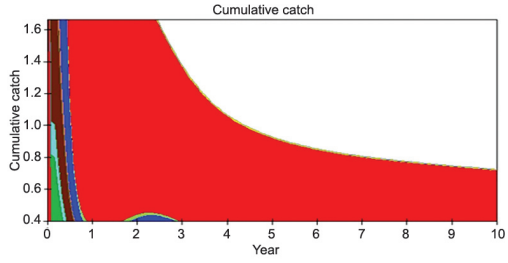
Cumulative biomass curve for GOM ecosystem

Trophic model of the Gulf of Mannar

Using the constructed ECOPATH model of the Gulf of Mannar, a scenario was built in ECOSIM with increasing effort at the rate of 10% per year for a period of 10 years. The parameters monitored in this scenario were cumulative catch and biomass.

It was observed that effort increase resulted in drastic reduction in the cumulative catch, and therefore effort control is very much necessary in the GOM ecosystem. The main group which would be affected are the small benthopelagics and small pelagics. Benthic crustaceans are relatively resistant to heavy fishing pressure in the GOM ecosystem.

The cumulative biomass curve also shows a decline in biomass of all groups due to increased fishing effort.



Cumulative catch curve for GOM ecosystem

MARINE HABITATS

Marine habitat restoration

Mangroves form an important habitat in the coastal ecosystem and the area occupied by this critical habitat has been reduced in several maritime states during the last three to four decades. Work on "Restoration of marine habitats" have benn done in Kerala and Karnataka during 2010.

Kerala

Nursery of three species of mangroves, *Rhizophora mucronata, Bruguiera gymnorrhiza* and *B. cylindrica* was developed at Moothakunnam, Ernakulam District through a Community based Marine Ecosystem Restoration Programme (CMERP). Five groups of school children supported by teachers and one village youth group participated in the programme. Three thousand numbers of plantable size seedlings were developed.

Mangrove nursery at Moothakunnam

The survival rates were high for all the three species - *R. mucronata* (78.8%) *B. gymnorrhiza* (77.1 %) and *B. cylindrica* (87.7%). Survival percentage (80.9%) was highest in the nursery of village youth.

Details of growth of mangrove propagules reared for 3 months at Moothakunnam village nurseries

	R. mucronata	*B. gymnorrhiza*	*B. cylindrica*
No. of leaves	2-7	3-10	4-6
No. of nodes	2-3	1 -5	2-4
Inter nodal length (cm)	2 – 12.7	8-3	2.5 -6.4
Shoot length (cm)	30 - 57.5	14-37.5	11-19
Shoot dia (mm)	3.4 – 6.8	3 – 9.1	1.86 - 8
Root collar dia (mm)	10.3 -21.52	11.6-18.96	4.3 – 7.87
Leaf area (cm^2 $leaf^{-1}$)	16.7-49.31	6.14 – 33.27	5.35 – 9.98
Leaf cover area (cm^2)	50.1-229.68	18.42-266.16	21.48-78.82

Mangrove seedlings loaded in the canoe for transportation to planting site

Planting of mangrove seedlings and initiation of ecofriendly aqua-farming practices

The seedlings were planted in selected open areas in the northern part of Vembanad Lake and in a traditional shrimp culture pond near the bunds as eco-friendly aquafarming practice with the involvement of villagers. The ground area planted was estimated as 900 m^2, with a spacing of 0.75 x 0.75 m in triangular pattern for planting. .

Net canopy photosynthesis for the planted mangroves was estimated as 0.029 g C hr^{-1} for *R.mucronata*, 0.026 g C hr^{-1} for *B. gymnorrhiza* and 0.0091g C hr^{-1} for *B.cylindrica*.

Karnataka

The region near Nethravathi River is dominated by *Sonneratia caseolaris* followed by *Rhizophora mucronata*. Patches of *Acanthus ilicifolius, Avicinea alba* and *Kandelia candel* were also observed.

Restoration trial in Karnataka

An experiment was initiated at Kuduroli for restoration of mangroves. The site is an elevated portion in middle of Gurupura estuary. Gastropods, fish eggs and jelly fish were observed in abundance in the area. 50 seedlings of *Rhizophora mucronata* were planted in bamboo of 1 foot length. The seedlings were collected from the wild and transferred to the bamboo and then transplanted along with bamboo for protection at the selected site.

Mangrove nursery at Mangalore

Mercury and arsenic pollution

Monitoring of Arsenic and Mercury in the ecosystem

The occurrence of Hg and As in the sediment and tissue of selected marine biota were monitored in the Arabian Sea and Bay of Bengal. The concentrations were either not detectable (ND) or below the permissible limit.

Concentration of mercury and arsenic in the sediment

	Hg μg^{g-1}	As μg^{g-1}
Tamil Nadu (Gulf of Mannar)	0.11	1.93
Andhra Pradesh	ND	12.64
Tamil Nadu (Chennai)	0.30	6.17
Kerala	0.27	ND
Karnataka	0.11	1.37
Maharashtra	0.16	12.79
Gujarat	ND	9.88

Health of coastal waters

Maharashtra

The environmental parameters showed wide seasonal variation. One significant observation was the low level of dissolved oxygen and moderately high Biological Oxygen Demand (BOD) in all the locations. High levels of carbon dioxide were also noted in these locations. The impact of urbanization on the near shore regions is evident in the water quality as indicated by the oxygen levels. However, high levels of nutrients were not observed.

Annual average hydrographic parameters in selected locations along Maharashtra coast

Parameters	Versova creek	Mahim creek	Gorai creek	Mahim nearshore	Reference (Juhu)
TDS	23.35 (35.5-8.0)	16.83 (28.7-4.0)	25.84 (38.05-12.8)	25.91 (40.0-13.0)	30.0 (39.9-18.4)
Turbidity (NTU)	68.47 (145-19.9)	49.00 (70.5 -23.2)	89.98 (16.5 -514.0)	79.14 (14.00 -140.0)	82.00 (40.2- 168.0)
Chl a (mg/m^3)	2.36 (4.94-0.33)	3.0 (10.1-0.1)	7.54 (20.9-1.8)	4.22 (9.7-0.4)	0.2 (0.86 -0.1)
BOD (mg/l)	4.83 (2.0 - 8.0)	5.0 (2.0 - 12.0)	6.0 (2.0 - 16.0)	5.0 (2.0 - 16.0)	5.0 (2.0- 10.0)
CO_2 (mg/l)	275 (180- 400)	219 (90- 390)	220 (30- 400)	215 (140- 280)	106 (20- 250)
D O (mg /l)	0.83 (0.2 - 1.28)	1 (0.46- 1.48)	1.0 (0.25- 1.73)	2 (0.49 - 2.9)	1.0 (0.25- 2.69)
Phosphate (µg-at/l)	4.0 (0.26- 28.23)	5.0 (1.7 - 37.6)	3.2 (2.8 - 3.7)	3.6 (2.6 - 5.9)	3 (0.4 - 4.7)
Nitrate (µg-at/l)	16.7 (7.2 - 33.4)	14.6 (0.5 -32.2)	20.0 (7.0 - 45.0)	21.9 (17.3 - 30.7)	32.4 (1.2 - 46.1)
Nitrite (µg-at/l)	1.5 (0.5- 2.5)	1.3 (0.6 - 1.9)	1.2 (0.1 - 2.6)	2.3 (2.1 - 2.6)	2.1 (2.0 - 2.4)
Silicate (µg-at/l)	27.7 (1.0 - 88.7)	13.0 (0.4 - 33.6)	8.5 (1.1 - 23.4)	6.6 (0.6 - 16.7)	11.2 (0.4 - 32.8)
Total Viable Count	10^6 - 10^4	10^6 - 10^4	10^6 - 10^4	10^6 - 10^3	10^4 - 10^3
Total Coliformes	10^4-10^3	10^4-10^3	10^4-10^2	10^4-Nil	10^4-10^2
E.coli	10^2	10^3 - Nil	10^2 - Nil	10^2 - Nil	10^2 - Nil

Karnataka

The environmental variations in selected outfall regions along Karnataka coast related to different types of anthropogenic activities such as oil refinery (Chitrapur), harbour (Panambur), dye industry (BASF) and fishing harbours (Kasba Bengare and Bunder) were monitored.

Seasonal variations in hydrographic parameters were observed in all the sites. Though the dissolved oxygen content (DO) was lower than the optimal level, the BOD and Chlorophyll values indicated that ecosystem is not degraded.

Annual range hydrographic parameters in selected outfall and riverine locations in Karnataka during January - December 2010

Parameter	Kasba Bengare	Bunder	Thaneerbhavi (R)	Kulur
TSS mg/l	2-71	5-104	0-203	0-81
Free CO_2 mg/l	0-10	3-11	0-11	3-10
DO ml/l	2.31-5.83	2.64-5.66	2.93-5.45	3.28-5.43
BOD ml/l	0.42-1.69	0.71-4.03	0.44-2.73	0.55-2.47
Phosphate µg-at/l	0.23-3.91	0.36-12.18	0.12-4.1	0.03-5.76
Nitrate µg-at/l	2.42-22.1	4.63-40.49	1.97-28.89	0.26-32.65
Nitrite µg-at/l	0.21-7.42	0.32-14.24	0.09-5.07	0.19-1.24
Silicate µg-at/l	9.04-175.8	10.49-162.36	9.43-151.68	18.16-151.32
Chlorophyll a mg/m³	0.201-14.85	0.43-16.41	1.073-32.01	0.667-30.63
Chlorophyll b mg/m³	0-0.719	0-1.249	0-14.31	0-32.8
Chlorophyll c mg/m³	0.496-6.26	0.124-7.16	0.21-11.41	0.032-11.77

Tamil Nadu

The water quality near the municipal sewage discharge point at Threspuram, the barmouth region at Punnakayal and the fairly unpolluted region near Tharuvaikulam was monitored continuously during the period. Though the hydrographic parameters showed variations, the water quality at Threspuram was in hypoxic condition. The pH was also low and the carbon dioxde content in the water was high compared to the other two sites.

Annual average hydrographic parameters in selected locations in the Gulf of Mannar (Tuticorin area) during January - December 2010

Parameters	Threspuram	Punnakayal	Thauvaikulam
pH	7.31 ± 0.10	7.6 ± 0.08	7.75 ± 0.11
D.O conc. (ml l^{-1})	0.94 ± 0.22	1.92 ± 0.12	2.12 ± 0.11
Productivity-GPP ($mgCl^{-1}day^{-1}$)	4.80 ± 1.80	3.05 ± 0.82	2.03 ± 0.78
Productivity-NPP ($mgCl^{-1}day^{-1}$)	1.86 ± 0.76	0.51 ± 0.19	0.38 ± 0.13
Chlorophyll (µg l^{-1})	15.89 ± 4.06	2.74 ± 0.54	1.12 ± 0.34
Ammonia (mg l^{-1})	1.114 ± 0.22	0.16 ± 0.05	0.09 ± 0.02
TSS (g l^{-1})	0.20 ± 0.03	0.17 ± 0.02	0.19 ± 0.02
CO_2 (mg l^{-1})	22.75 ± 6.28	3.67 ± 2.50	1.42 ± 1.42
NO_2 (µg l^{-1})	10.50 ± 4.53	0.78 ± 0.19	0.74 ± 0.32
NO_3 (µg l^{-1})	0.01 ± 0.001	1.18 ± 0.31	1.78 ± 0.44
PO_4 (µg l^{-1})	10.49 ± 1.84	2.35 ± 0.65	0.74 ± 0.19
SiO_2 (µg l^{-1})	0.43 ± 0.39	0.34 ± 0.31	0.31 ± 0.23
BOD	1.80 ± 0.55	1.39 ± 0.52	1.34 ± 0.45

Kerala

Water quality was assessed at three sites, Edayar, Irumpanam and Cochin backwaters near IFP Jetty and one reference station at Aluva. The mean values for all the parameters in all the four locations were within the normal range except for ammonia and dissolved oxygen at Irumpanam, where, ammonia was above permissible level and dissolved oxygen was low.

Average annual hydrographic values at selected locations along Kerala

	Edayar	Aluva (Ref.)	Irumpanam	IFP Jetty
Water pH	6.70	6.72	6.13	6.89
SiO_3 µg at/l	96.35	88.79	69.09	48.82
PO_4 µg at/l	0.68	0.15	21.78	2.38
NO_2 µg at/l	0.54	0.26	1.44	0.68
NO_3 µg at/l	7.19	9.41	2.62	2.99
Chl *a*, mg/m^3	0.37	0.54	2.31	0.88
TSS, mg/l	12.22	9.79	13.61	26.45
NH_3 µg at/l	8.79	2.38	34.71	9.05
GPP, mg C/l/hr	0.05	0.04	0.05	0.06
NPP, mg C/l/hr	0.03	0.02	0.03	0.01
DO, ml/l	3.84	4.52	4.44	3.43
BOD, mg/l	1.42	1.22	1.82	1.15
CO_2, mg/l	6.98	5.07	14.72	4.04
Turbidity, NTU	17.72	9.08	6.53	16.03

Andhra Pradesh

In the coastal region of Visakhaptnam, five sites were regularly monitored *viz*. Visakhapatnam Port /Fishing Harbour, sewage outfall region, Mangamripeta, and coastal waters at 10 and 15 m depth. Among these sites, water quality was found to be affected in the sewage outfall area where carbon dioxide level was high and dissolved oxygen low. The productivity was also low.

Annual average hydrographic parameters in selected locations in the nearshore waters of Visakhapatnam during 2010

Location	CO_2 mg/l	DO mg/l	BOD mg/l	GPP mgC/l/hr	NPP mgC/l/hr	Chl a mg/m^3	TSS mg/l	NH3 µgat./l	PO4 µgat./l	NO3 µgat./l
Vizag Port / Fishing Harbour	0.00	2.74	1.99	0.04	0.02	0.22	0.03	0.22	0.18	0.04
Sewage /Outfall	22.40	0.54	0.80	0.00	0.01	0.02	0.12	6.43	1.36	0.11
Mangamaripeta	0.00	3.94	2.25	0.02	0.03	0.15	0.03	0.08	0.11	0.04
Coastal waters (10 m depth)	0.00	3.97	2.67	0.16	0.02	0.45	13.17	0.00	0.35	0.07
Coastal waters (15 m depth)	0.00	3.89	1.83	0.51	0.11	0.91	12.62	0.00	0.80	0.04

Marine Debris

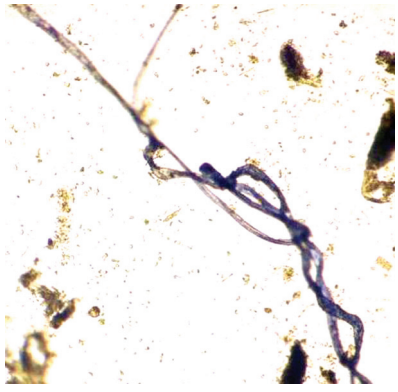
Coastal / Beach debris

Tamil Nadu (Gulf of Mannar region)

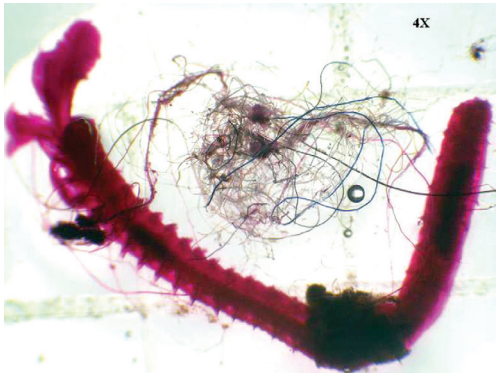
The quantity of non-biodegradable substances, the highest at the harbour beach,Tuticorin ranged between 78.7 – 850 g/m^2 with a mean of 313.6 ± 63.3 g/m^2 followed by Threspuram beach (256.1 ± 42.2 g/m^2) and Tharuvaikulam beach (173.7 ± 29.3 g/m^2). The relatively clean Mottaigopuram beach recorded the least value of 35.8 ± 7.3 g/m^2.

Karnataka

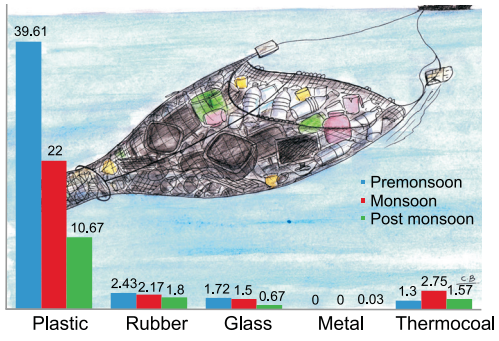
Plastics were monitored on three beaches Chitrapur, Panambur and Thaneerbhavi. Chitrapur had the highest rate of marine litter of 963.72 g/m^2 followed by Thaneerbhavi 541.2448 g/m^2 and Panambur 97.5667 g/m^2 from July to December 2010.



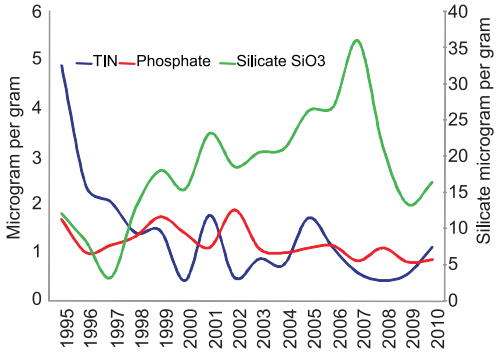
Plastic strand found in twisted form in the gut of mackerel



Polychaete larvae entangled with assorted plastic



Seasonal variation (% occurence - spread area per sqm) of non-biodegradable material in the coastal area off Kochi



Decadal variation of nutrients in the coastal waters off Kochi

Kerala

Occurrence of non-biodegradable waste in an unit area along Calicut beach was estimated at 0.295 g/m^2 and along beaches of Kochi as 20 to 70 g/m^2 .

Impact on fauna

In Mangalore, during routine examination of gut of mackerel and oil sardine from the trawl boat landings nylon thread pieces of length 1 to 4 mm were observed. Entangled nylon thread were also observed in the benthos samples.

In the trawl fishing area off Mangalore (N 12° 48' E 74° 42'), the quantity of non-biodegradable material collected ranged between 0.32 and 0.82 g/m^2. The marine debris in the fishing ground off Calicut ranged from nil to 117 g/haul.

Decadal changes in the coastal sediment quality

The data on hydrographic variations and sediment quality of the coastal ecosystem (upto 30 m depth, off Kochi, in the Arabian Sea) collected since 1995 to 2010 was digitized. Decadal changes in the nutrient level which is an indication of eutrophication was evaluated and the changes in heavy metal content in the sediment, a pollution indicator was also compared.

Evaluation of dissolved nutrients

The annual averages of total inorganic nitrogen (TIN) and dissolved phosphates were consistently lower than the values in 1995 indicating that the coastal waters have not been negatively impacted. The annual average TIN ranged between 0.42 µg at l^{-1} and 2.36 µg at l^{-1} during 1996 to 2010 and the dissolved phosphate levels were generally lower than the levels (1.69 µg at l^{-1}) in 1995 except during 1999 (1.74 µg at l^{-1}) and 2002 (1.89 µg at l^{-1}).

Dissolved silicate levels were found to increase during the last decade. The average annual silicate levels were lower than the levels in 1996 (12.031 µg at l^{-1}) only during 1997 (8.12 µg at l^{-1}) and 1998 (3.2 µg at l^{-1}). From 1998 onwards, the silicate levels have increased and were highest in the year 2007 (35.04 µg at l^{-1}).

Evaluation of changes in coastal benthic trace metal levels

A digitized database on the levels of heavy metal (Cu, Zn, Cd, Pb, Mn, As, Hg, Fe) in water, sediment and tissue of various marine fauna was developed by recording the results of more than one lakh analyses in the Environment Laboratory at CMFRI Kochi since 1988.

Cadmium and copper in the coastal sediment

For the past one and half decades, the cadmium and copper levels in the sediment were within the permissible limit and did not go beyond the limit even during the monsoon period indicating the quality of benthic system with respect to Cd and Cu levels.

Zinc in the coastal sediment

The level of zinc in the coastal sediment was low and remained well within the permissible limits set by the World Health Organization and

only 1.1% of the samples analyzed had slightly increased values. The variations were mostly during March 1994 and May 1999.

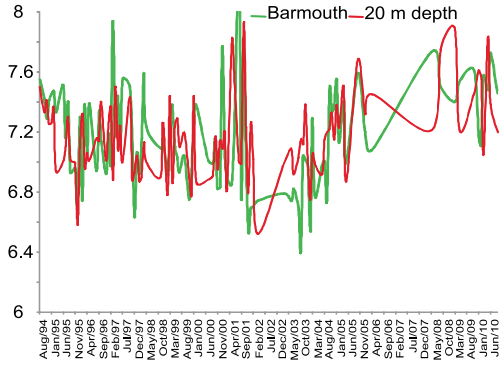
Coastal benthic pH

The acid-base nature of the coastal sediment since 1990 was analyzed. The general health of the sediment was evaluated as 'good' as the pH values remained within the normal levels and fluctuations did not persist for long periods. Changes were more in the shallow regions compared to the offshore deeper regions.

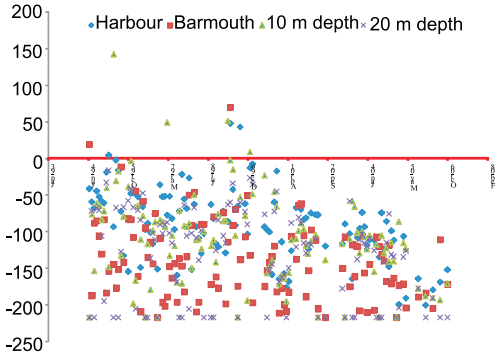
Impact of bivalve farming

Extensive mussel farming in Padanna Estuary (682 units) has influenced its oxygen budget. Diurnal observation of dissolved oxygen levels monitored from the estuary at 2 hourly intervals for 24 hour period indicated that the estuary remained heterotrophic as detailed below:

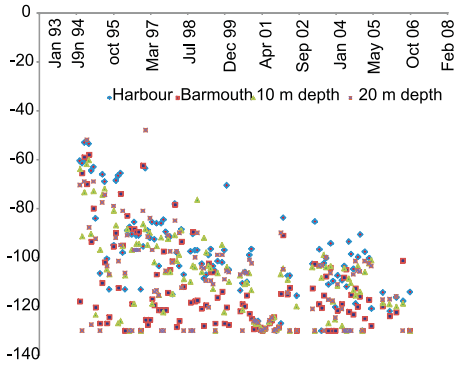
Date of observation	P (ml O_2/l/day)	R (ml O_2/l/day)	P/ R
18 and 19-12-2010	0.196	0.322	0.608
1 and 02-03-2011	0.820	1.430	0.573



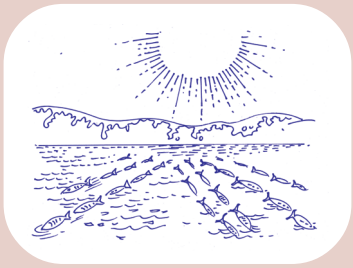
pH of the coastal sediment in the barmouth region and at 20 m depth off Kochi from 1994 to 2010



Zinc in the coastal sediment off Kochi: Arabian Sea - Values in comparision to the permissible limit (270 µg/g set by NOAA)

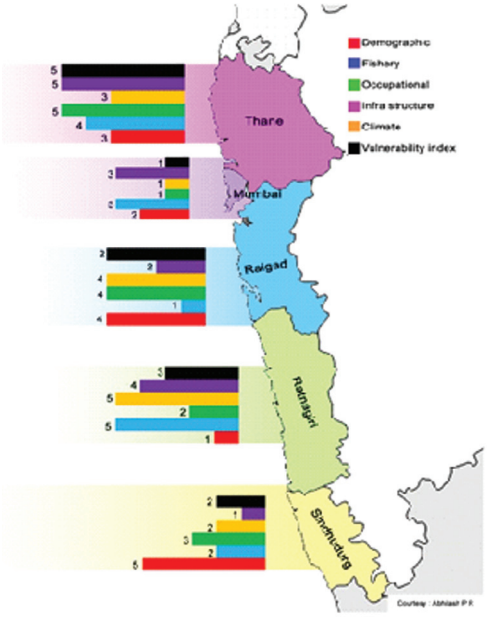


Copper in the coastal sediment off Kochi : Arabian Sea -Values in comparision to the permissible limit (108 µg/g set by NOAA)



CLIMATE CHANGE

Vulnerability assessments aim at identifying which localities are most at risk and to understand why. To assess vulnerability of coastal villages in the districts of Maharashtra and Kerala to climate change, 15 sub-indicators under five indicators, namely, demography (population and literacy), infrastructure (types of houses, number of co-operative societies and community centres), occupation (labourers and owners of fishing boats), climate variabilites (number of anamolous months of sea surface temperature, rainfall, sea level, meridional wind velocity and chlorophyll concentration) and fisheries (number of mechanised/motorised and non-motorised craft and fish catch fluctuations) were selected. The functional relationship (positive or negative) between each sub-indicator and vulnerability level was identified and normalised so that they lie between 0 and 1. After normalization, the average index (AI) for each sub-indicator was determined and then the overall vulnerability index was computed.



Vulnerability Index (VI) for coastal villages in the districts of Maharashtra

Vulnerability Index (VI) for coastal villages in the districts of Maharashtra

Among the five coastal districts of Maharashtra, the Vulnerability Index was highest for Thane (0.122) followed by Raigad (0.110). The highest vulnerability of Thane District was due to relatively poor infrastructure such as existence of large number of *kutcha* houses and less community activities; and occupational pattern such as a large number of fishermen remaining as labourers. In Raigad District, illiteracy and presence of a large number of labourers were found to be the reasons for high vulnerability. Vulnerability related to climate anomalies and fisheries fluctuations was highest in Ratnagiri District. Climate variability was high off Raigad too.

Vulnerability rank of coastal villages in the districts of Maharashtra

District	Demography	Infrastructure	Occupation	Climate	Fishery	V I
Raigad	0.78	0.41	0.67	0.47	0.42	0.110
Thane	0.46	0.88	0.97	0.25	0.51	0.122
Mumbai	0.12	0.65	0.17	0.23	0.50	0.070
Ratnagiri	0.32	0.72	0.40	0.50	0.72	0.107
Sindhudurg	0.82	0.31	0.55	0.25	0.48	0.096

Higher the rank, more is vulnerability to climate change

Vulnerability Index (VI) coastal villages in the districts of Kerala

Among the coastal villages in the nine districts of Kerala, the Vulnerability Index was the highest for Alappuzha (0.122) followed by Kozhikode (0.121) and Thiruvananthapuram (0.120). The highest vulnerability of Alappuzha District was due to demographic features such as relatively high population density in coastal villages, and occupational pattern such as a large number of fishermen remaining as labourers. Vulnerability related to climate anomalies was highest in Kollam District; and that related to fisheries fluctuations was high off Thiruvananthapuram District.

One of the sub-indicators used under climatic variability was net area of sea accretion/erosion in the coastal districts of Kerala. It was found that compared to the year 1996, sea erosion was maximum (63 ha) along Kollam District. On the other hand, accretion of 173 ha was noticed along Thiruvananthapuram District.

Vulnerability rank of coastal villages in the districts of Kerala

District	Demography	Infrastructure	Occupation	Climate	Fishery	V I
Thiruvananthapuram	0.62	0.41	0.74	0.51	0.72	0.120
Kollam	0.27	0.48	0.19	0.72	0.26	0.077
Alappuzha	0.78	0.45	0.94	0.48	0.41	0.122
Ernakulam	0.19	0.19	0.21	0.63	0.18	0.057
Thrissur	0.11	0.45	0.04	0.56	0.14	0.052
Malappuram	0.63	0.29	0.44	0.46	0.32	0.086
Kozhikode	0.73	0.76	0.66	0.49	0.40	0.121
Kannur	0.04	0.37	0.01	0.55	0.15	0.044
Kasaragod	0.08	0.19	0.11	0.51	0.06	0.038

Higher the rank, more is vulnerability to climate change

Development of vulnerability index and ranking brings about preparedness among the governments to evolve suitable policies so as to reduce the risk of climate change.

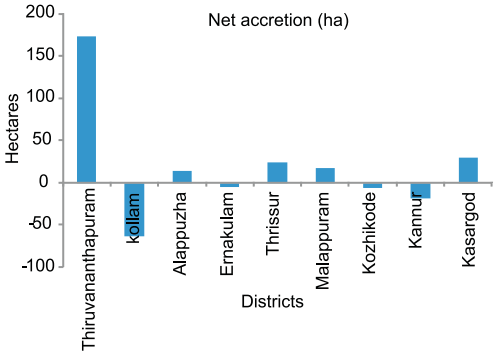
Awareness porgramme for fishermen of Kovalam

An Awareness Workshop on Climate Change and Fisheries was organised at Kovalam (Kanchipuram District, Tamil Nadu) on 25th March, 2011. The Assistant Director of Fisheries, Government of Tamil Nadu presided over the workshop. Scientists of CMFRI made technical presentations. About 70 fishermen participated in the workshop. The information on climate change presented by the scientists was new to them. They showed keen interest and raised their doubts and questions during the interaction with scientists. The fishermen also shared their experience with the scientists.

The Consortia partners include four research organizations and five NGOs. This project aims to tackle the climate change adaptation problems of floods and the decreasing livelihoods resilience of rural households to deal with climate variability and change, and to realise new opportunities for livelihoods sustainability. Taking knowledge based natural resources management approach, the project is trying to build resilience to climate impacts into resource-based livelihoods in flood affected districts of Maharashtra and Orissa.

The specific objectives of the climate change adaptation consortia project, in brief, are:

- Identification of current and future risks to livelihoods due to climatic variability
- Development of drought indices to facilitate Early Warning System (EWS) for promoting its use in adaptation by farmers and other stakeholders
- Develop community based sustainable rural livelihoods strategies to minimize adverse climatic impact in droughts as well as floods prone vulnerable districts
- Capacity building of the stakeholders on strategies for alternate livelihoods strategies in future climate change.



Area (ha) of sea accretion/erosion in the coastal districts of Kerala

Six clusters, each cluster consisting of one to four villages were formed. Five clusters were from Maharashtra and one from Orissa. Cluster 1: Alibag, Saswane, Bodani, Mandwa; Cluster 2: Ekdara, Murud, Rajapuri; Cluster 3: Mora, Ulwa, Vasheni; Cluster 4: Salav, Korlai, Nandgaon; Cluster 5: Karjat, Neral; Cluster 6: Ganjam (Orissa)

Baseline survey has been initiated with visits to the study areas followed by formation of village level and family level proforma/ questionnaire. Baseline survey has been undertaken in all 15 villages of 5 clusters in Raigad District of Maharashtra.

PFZ advisories were gathered for December 2010 and January and February 2011 from INCOIS, Hyderabad and awareness was created among surveyed fishers regarding utility of these advisories and how the project will disseminate these advisories through m-Krishi: Fisheries Service.

The salient observations of baseline survey in the five clusters are as follows:

Knowledge about the climate change and PFZ forecasting was found to be very less or negligible in the villages. Therefore, awareness and dissemination of PFZ advisories and GPS use accompanied with NCDC schemes for offshore and deepsea fishing will help the fishers. PFZ advisories can be disseminated to fishers through m-Krishi-Fisheries Services on their mobile screen which will help them to find fish catch without wasting fuel and time.

All the fishers were of the opinion that pollution and high fishing effort are the reasons for low catches. Fish storage boxes and training of marketing were sought after by most of the fishermen. Fishes are dried on cement platforms in sunlight. Unseasonal rain is a problem nowadays, so fish dryers are the need of the fishers.

A project launch workshop was held at CMFRI, Kochi on February 4 and 5, 2011, with the main theme of "Harnessing the beneficial effects of climate change on marine organisms". The objectives of the project are: (i) To enhance the resilience of Indian marine fisheries and mariculture to climatic variabilities and climate change through development and application of suitable management measures and technologies; (ii) To demonstrate season and site specific technologies on mariculture for adapting to current climate risks; and (iii) To enhance the capacity of fisheries scientists and other stakeholders in climate resilient marine fisheries and mariculture research and its application. The project has three major components on capture fisheries, mariculture and technology demonstration.

The technical programmes of the project are as follows:

Capture Fisheries: Assessing the changes in distribution and abundance; evaluating the shift in spawning season, strength and recruitment into fisheries; determining quantitative and qualitative food availability, especially to the spawners and juveniles; finding relationships between climatic and oceanographic variables on distribution, spawning and food availability; developing models on the impact of phenological and climatic changes on fish catches; assessing changes in the trends in Potential Fishing Zone (PFZ) forecasts; suggesting adaptation options to marine capture fisheries sector.

Mariculture: Assessing the spawning success of culturable species under controlled conditions in different seasons; assessing the egg development, and larval and juvenile growth under controlled conditions in different seasons; assessing the impact of different temperatures, salinities and pH on larval rearing and growth of selected ornamental fishes; evaluating the reproductive, multiplication and growth potential of selected species of phytoplankton and zooplankton under different hydrographic regimes; monitoring and manipulating hydrographic parameters in controlled experiments; suggesting the suitable species and season for undertaking hatchery and mariculture activities.

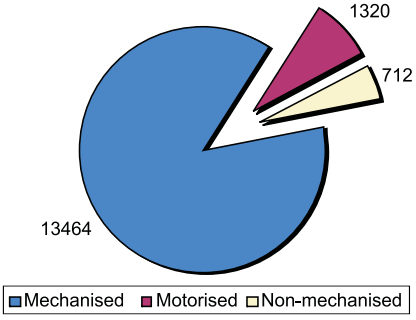
Technology Demonstration: To demonstrate cage culture potential for high value fishes like seabass *Lates calcarifer* and cobia *Rachycentron canadum* in Karwar waters in increased temperature regime and to develop energy saving culture practices in coastal waters.

The expected output of the project are (i) enhancing the resilience of Indian marine fisheries and mariculture to climatic variabilities and climate change through development and application of suitable management measures and technologies; (ii) demonstration of season and site specific technologies on mariculture for adapting to current climate risks; and (iii) enhancing the capacity of fisheries scientists and other stakeholders in climate resilient marine fisheries and mariculture research and its application.

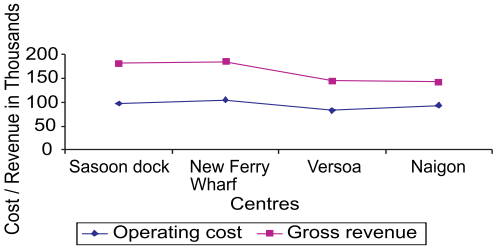
Other objectives of the project are (i) to evaluate CO_2 utilization capacity of different species of seaweeds; and (ii) to quantify CO_2 utilization potential of seaweed biomass in the Indian waters. The schedule of activities are collection of seaweeds; maintenance in laboratory at Mandapam; conduct of experiments on growth and CO_2 utilization by different species of seaweeds exposed to different levels of CO_2.

The seaweed *Kappaphycus alvarezii* has been collected and experiments are in progress. Initial results suggest that the seaweed has good carbon sequestration potential.

SOCIO-ECONOMICS



Gross private investment in fishing equipment in India during 2009-10 (Rs. in crores)



Economic performance of multiday trawling (>6 days), Maharashtra

Resource management, Economic sustainability and Socio-economics

The gross revenue from the marine fish landings during 2009-10 at the point of first sales (landing centre) was estimated at Rs.19,753 crores, registering an increase of 14% over the previous year. The gross revenue from the marine fish landings at the point of last sales (retail market) was estimated at Rs.28,511 crores, showing an increase of 14.35% over the previous year. The unit price of marine fish at the landing centre was Rs.61.88/kg and at retail market was Rs.90.13/kg.

The gross private investment on fishing equipment in India (2009-10) was estimated at Rs.15,496 crores**,** out of which the investment on mechanized crafts worked out to Rs.13,464 crores (87% of the total investment), followed by the motorized crafts, Rs.1,320 crores (8.5%) and the non-mechanised crafts, Rs.711.6 crores (4.5%). The per capita investment per active fishermen during 2009-10 worked out to Rs.3,11,799 in the mechanised sector, Rs.32,870 in the motorised sector and Rs.17,205 at non-mechanised sector.

Among the east coast states, in the case of multiday trawl fishing of 2-5 days duration in Andhra Pradesh, the capital resource use was efficient in Kakinada with a lower operating ratio of 0.42 against 0.58 at Bhairavapalem. For the multiday trawl fishing of 5-10 days duration, the capital productivity was efficient in Andhra Pradesh with lower operating ratios of 0.33 and 0.63 at Kakinada and Bhairavapalem**.**

In Goa, the operating cost per trip of a multiday trawl fishing (3-5days) worked out to Rs.59,194 and the gross revenue per trip worked at Rs.1,01,346. The average diesel consumption was 1,185 litres per trip, which constituted 40 per cent of the gross earnings. In the case of singleday purse-seiners in Karwar, the operating cost and gross revenue per trip were Rs.16,230 and Rs. 28,024 respectively and the operating ratio was 0.58. The singleday trawlers operating in Karwar consumed an average 77 litres of diesel /trip. The operating cost and revenue per trip were Rs. 4,455 and Rs. 4,998 respectively. The net profit was Rs. 543/ trip and the operating ratio was 0.89.

The net operating income per trip for a multiday dolnet operation was higher during the post monsoon trip at Rs.1,74,996 than pre monsoon trip, which worked out to Rs.38,861 at Naigon landing centre in Thane. A similar trend was observed for single day dolnet operation, multiday gillnet and trawlnet operations. The operating cost per trip of multiday purse seine operation (2-5 days) at Mirkarwarda of Ratnagiri worked out to Rs.17,681 with a gross revenue of Rs.56,592. The capital productivity ratio worked out to 0.31.

Market structure and price behaviour

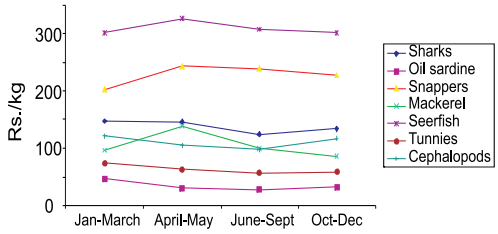
The marketing efficiency analysis of fish marketing in the different markets indicated that the price spread varied across the species and its size. In case of small size, the producers share of the consumers rupee was highest for rock cods (85.37%) followed by pomfrets (79.81 %), catfishes(77.18%) and lowest for clupeids (47.78), cephalopods other than sepia (49.18%), rays (55.71%) and sharks (55.71%).

Analysis of price behaviour in Goa showed that at landing centre level the average price varied from Rs.24/kg for silverbellies to Rs.330/kg for seer fishes. At retail level the fish prices varied from Rs.27/kg for silverbellies to Rs.453/kg for large sized pomfrets. The producer's share in the consumer's rupee varied from 45% for flat fishes to 92% for seer fishes.

Seasonal fluctuations in retail fish prices in Goa

Analysis of fish price behaviour at landing centre and wholesale markets in Tamil Nadu showed that the average minimum price was recorded for oil sardines at Rs.25/kg and the maximum for seer fish at Rs.325/kg. The price variation for different sizes was clearly observed in the study. At retail level, the minimum price was recorded for oil sardines at Rs.35/kg and the maximum price was recorded for seer fish at Rs.450/kg.

Size wise variation at the landing centre price was highest for seer fish, pomfrets, penaeid prawns, non-penaeid prawns and sharks. The difference between small and large sized seer fish in the landing centre was Rs. 50/kg. In whole sale market, highest price was recorded for seer fish (Rs.325/kg) followed by penaeid prawns (Rs.310/kg). Size-wise variation in retail market was highest for seer fish (Rs.400 for small size fish, Rs.450 for large size fish/kg) followed by penaeid prawns. (Rs. 30/kg).



Seasonal fluctuations in retail fish prices in Goa

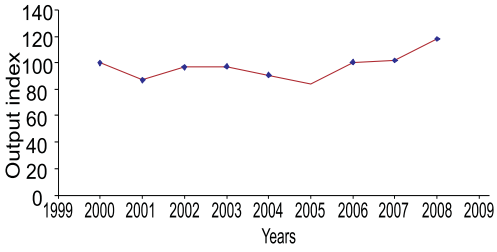
The fishermen share in the consumer rupee was high for varieties like non-penaeid prawns (97.14%), pomfrets (96.42%) and penaeid prawns (90.32%) indicating an efficient marketing system existing for these premium varieties. In the case of oil sardine, mackerel and silver bellies, fishermen earned nearly 85% of the consumer rupee.

Total Factor Productivity

The total number of mechanised units in Kerala increased from 4,000 in 1980 to 5,088 in 1998 and then increased to 5,514 in 2005. The fishing effort in terms of number of units and fishing hours declined for most of the mechanised units like trawlers, purseseiners gillnetters and hooks and lines and increased in the case of liners and ring seiners during 1999-2008 period. In case of motorised units the actual fishing hours declined from 6.26 million hours in 1999 to 4.96 million hours in 2008.

The average estimated diesel consumption in the fishing industry in Kerala was 105 million litres. In real terms (at 2005 prices) the fuel cost increased from Rs.1,634 million in 1999 to Rs.3,435 million in 2008. The annual kerosene consumption by the motorised units declined from145 million litres to 125 million litres.

The estimated input index showed a positive growth of 1.12% and the total factor productivity growth was -1.44% in Kerala during the period 1999-2008.The average employment at primary sector in the



Growth in output index in Indian marine fisheries (1999-2008)

marine fisheries sector of the state was 18 million labour days during the period 1999-2008. The estimated growth in output index during 1999-2000 for the marine fisheries sector in India is 1.8%.

Assessment of literacy, income and health status of fishers in India

The analysis of the literacy level of the selected marine fishers in the coastal states of Kerala, Tamil Nadu and Puducherry indicated that the literacy rate was highest in Kerala followed by Puducherry and Tamil Nadu at 87.2, 80.1 and 77.3% respectively. The analysis on the access to educational institutions indicated that the primary schools were invariably accessed at less than a kilometer and high schools and colleges within a range of 1-3 km and 3-8 km respectively. Professional colleges were located a distance of 7-15 km in the selected states.

The analysis of health status of the respondent household across the selected fisher families in Kerala, Tamil Nadu and Puducherry revealed that there wasn't any case of discontinuation of the vaccination regime for children/ infants. In addition there wasn't any mortality of mother or child during child birth which all indicated the high level of awareness of health.

The income analysis across the selected states indicated that the respondents involvement in non fisheries activities were found to be significant (25% of the total selected fishers) on account of low level of income and seasonality of fishing operations. The level of indebtedness of the fishers across the states indicated that the indebtedness was reported high in Puducherry (77.14%) followed by Tamil Nadu (54.28%) and low in Kerala (42.40%)

Fisheries governance, livelihoods, gender and welfare

The dimensions and extent of social security nets covered by the maritime states was characterised. Fuel subsidy lies on the top of the various welfare schemes offered by the State. A similar trend has been observed in other states also. Access to means of production is one factor that determines the intra-sectoral inequality. Significant difference observed in the monthly per capita expenditure (MCPE) in Karnataka varied between the owners and labourers significantly.

A dry fish market at Mangalore

Kerala is unique in the case of provision of old age pension to fishermen above 60 years . The scheme was started in 1987-88 under the Kerala Fishermen Welfare Fund Board which was established in 1985. An amount of Rs 49.85 crores (with a per capita dividend of Rs. 2343) was disbursed as pension to 2,12,746 people (consisting of fishermen, widows and allied workers who are members of the Board) during 2006-11. Though Tamil Nadu has started a Welfare Fund Board in 2007 they are yet to start a pension scheme exclusively for fisherfolk.

Rural indebtedness and microfinance

In south west zone, comprising Kasaragod, Calicut and Ernakulam districts of Kerala the average indebtedness of fisheries households in mechanized sector of non members of Micro Finance Institutions (MFI) was Rs. 95,000/- and that of members was Rs. 48,000/-. In motorised sector, the indebtedness of non-members was Rs. 2,65,000/- and that of MFI members was Rs. 54,000/-. But in the traditional sector MFI members' indebtedness was Rs. 50,000/- and that of non-members was

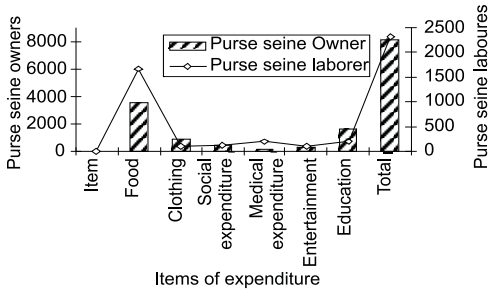
Rs. 20,000/- which indicates the necessity of strengthening the MFI ventures in the traditional sector. It was also observed that the MFI member fisherfolk have a repayment capacity to the tune of 38 %.

In south-west zone comprising Mangalore of Dakshina Kannada District of Karnataka, the average indebtedness in the primary sector was found to be Rs. 4.25 lakhs, in the secondary sector, Rs. 3.42 lakhs and in tertiary sector, Rs. 32,000.

In Sindhudurg and Ratnagiri districts of Maharashtra in the northwest zone, the level of indebtedness among fisherfolk was observed to be 95% among non-members of MFIs. The level of indebtedness is lesser for members of MFIs and their repayment capacity is to the tune of 54 %. There existed a significant difference in the level of indebtedness across the member fisherfolk of MFIs and non-members on account of their higher repayment capacity, less risk involved and easiness in availing credit.

In Visakhapatnam District of north-east zone, the level of indebtedness among fisherfolk in mechanized sector was 59% and that in motorized sector was 90%. It was also observed that the MFI member fisherfolk have tremendous repayment capacity of the loans.

The level of indebtedness got reduced to the tune of 75% after joining MFI and their repayment capacity improved to the extent of 65% in mechanized sector. But in motorized/ non-motorized sector level of indebtedness increased to the tune of 65% after joining MFI, but in the mean time their repayment capacity also got improved to the extent of 53%.



Monthly expenditure pattern of Purseseiner owners

Women empowerment

The earner-dependent ratio which provides an understanding on the dynamics of income generation in households indicated that fish retailers and vendors constituted larger earner dependent ratio. The larger earner dependent ratios clearly spelt the growing importance of continuing business for fisherwomen.

Economic empowerment measured on the basis of income sharing, freedom on expenditure, sharing of expenditure, saving and borrowing pattern and discrimination on gender differentials. The results revealed that the retailers and vendors does not share their income much and also had increased freedom on expenditure. The household expenditure studies indicated an increased share of fisherwomen expenditure on providing necessities of life. The expenditure on assets among respondent fisherwomen indicated that mostly the expenditure was incurred on jewels and home appliances. The saving pattern inferred that self help groups constituted the major destination for savings.

Marketing at Versova Fishing Harbour

Social empowerment indicators were measured through participation in social events, mobility, networking, assistance, decision making capacity, access to information sources and health care facilities etc. It was found that across occupational groups the fisher women were socially empowered with mobility, support, sizable networking, involvement in the helm of affairs and decision making capacity. The fisherwomen across all groups were possessing adequate level of knowledge about health and nutritional aspects.

The political empowerment analysed in terms of participation in election process, membership in political organization, exercising franchise, awareness on the political system indicated substantially high level of empowerment in terms of awareness, registration, voting, possession of voters identity card and voting as per own choice. Even though politically oriented and inclined, membership in political institution was less.

The different occupational groups were legally empowered with family members involved in making law and order, and clear cut awareness on women and human rights. The study portrayed the improving level of empowerment of fisherwomen across the different occupation.

Markets, trade and environment

The marine products exports from India continue to surge up new heights and unabated by global recession. During 2010, the growth assumed higher significance with the exports touching around 2.3 billion dollars by January 2011 and is expected to touch 2.5 billion dollars with an expected growth of 15% in terms of quantity and value. The appreciation of the Indian rupee hasn't much affected the export earnings. The reason for the sustained increase in export is due to the demand for raw fish rather than value added products from the retail outlets as the buyers opted for cheaper fish on account of lower income and increasing unemployment.

Retail fish market at Panaji, Goa

The Growth Constancy Retention Ratio for analyzing the export performance of fin fishes indicated that the South East Asian countries (45.5), China (38.2) and some of the EU countries (27.2)registered a higher ratio followed by Middle East Countries (18.3) for the post WTO period.

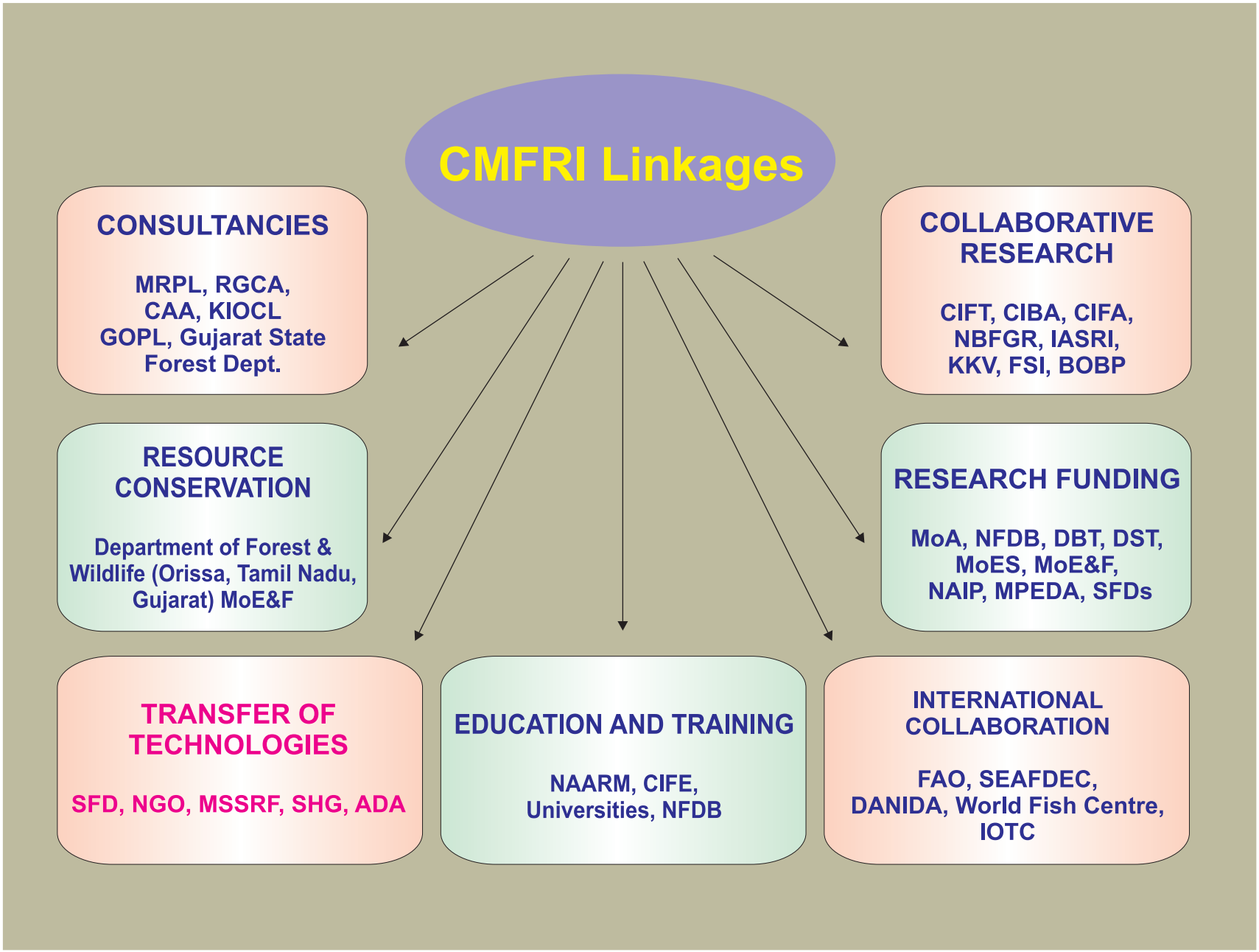
Frozen shrimp accounted for 46.92% of the earnings followed by frozen fish and frozen cephalopods. European Union is the prime geographic destination followed by US, China and South East Asia. The tradeoff between the domestics process and the international process of high value species like shrimps, cephalopods , pomfrets and seer fish were worked out. It was found that even though the domestic prices were on an average 20-25% more than the export prices, due to the export economies of scale the export flow continues to be on the higher side.

Fishery subsidies greatly impact the sustainability of fishery resources. Subsidies that reduce the cost of fisheries operations and those that enhance revenues make fishing enterprises more profitable than they would be otherwise. The global fisheries subsidies are estimated at 30 billion dollars which comprises of good, bad and ugly subsidies on account of their role in investment or disinvestment to the natural capital assets. The global subsidies are valued at 35–40% of the value of total fisheries production. Fuel accounts to more than 27.7%. The good subsidies account to 27% of the total subsidy in terms of fisheries management, research and conservation programmes. Developed countries account for more than 68% of subsidies, and developing countries the remaining 32%. However on a per country basis, developed countries provide more than three times as much subsidy as developing countries.

In the context of India, the amount of fisheires subsidies provided is much less with less than 8% of the total value, eventhough challenged internationally .The marine fisheries sector in India is a subsistence fishing and much different from the factory/ commercial fishing of developed countries. In addition, the fuel subsidy provided contributes to less than 10% of the total value of landings. But on the other side the welfare measures, saving cum relief, housing and other transfer payment adds to the subsidy component in the Indian context.

The analysis of the short run and long run gains on the SPS and compliance measures by the exporter's analysis indicated the huge cost of investment required for the compliance of EU approval and HACCP implementation. The gains weren't significant due to non capacity utilisation of the processing plant and lack of raw materials. The processing plants which have implemented the compliance investment for the EU approval are yet to break even their cost of investment even after 8 -10 years on account of low capacity utilisation to the tune of 22-25%.

Sorting of fish at Kalamukku Fishing Harbour, Ernakulam


CMFRI Linkages
CONSULTANCIES
MRPL, RGCA, CAA, KIOCL GOPL, Gujarat State Forest Dept.
COLLABORATIVE RESEARCH
CIFT, CIBA, CIFA, NBFGR, IASRI, KKV, FSI, BOBP
RESOURCE CONSERVATION
Department of Forest & Wildlife (Orissa, Tamil Nadu, Gujarat) MoE&F
RESEARCH FUNDING
MoA, NFDB, DBT, DST, MoES, MoE&F, NAIP, MPEDA, SFDs
TRANSFER OF TECHNOLOGIES
SFD, NGO, MSSRF, SHG, ADA
EDUCATION AND TRAINING
NAARM, CIFE, Universities, NFDB
INTERNATIONAL COLLABORATION
FAO, SEAFDEC, DANIDA, World Fish Centre, IOTC

Patents and Intellectual Property Management and Technology Transfer/Commercialisation Unit (ITMU)

The primary objective of IP management units is to protect the intellectual wealth generated through our research and commercialisation of IPR enabled technologies through public/ private partnership leading to their efficient transfer. The patents are filed through ITMC (Institute Technology Management Committee) and ITMU (Intellectual Property Management and Technology Transfer/ Commercialisation Unit). The foreign patent cases are processed by ATMC in ICAR through ITMC/ITMU.

Functions of ITMU

- IP protection, maintenance, management
- Patent filing, inviting expert opinion from patent attorney/IPR expert
- ITMC will duly record the reasons for acceptance/rejection of each patent proposal
- Correction/ Rectification/ Updation of Primary Information
- Technology transfer/commercialisation
- Taking external legal and business advice wherever required

The ITMU also handles matters related to creating awareness of IP issues and commercialisation of viable technologies. ITMU of CMFRI also invites expert opinion under a confidentiality agreement with empanelled patent attorneys.

Activities taken up by ITMU of CMFRI during 2010-2011

Application and maintenance of the IP assets of CMFRI

Patents have been either submitted in the patent office (Chennai) for complete/provision application and/or requested for examination.

Details of Patents filed during 2010-11

Patent application filing No.	Year	Title	Status
1543/CHE/2009	2009	A method and composition for land-based culturing of pearl oyster in marine body and device therefore	Examination request filed
31/CHE/2010	2010	A device for breeding and culturing marine fish in open sea	Examination request being filed
32/CHE/2010	2010	Formulated feed for marine ornamental fishes and a process thereof	Examination request being filed
2065/CHE/2010	2010	A process to concentrate anti-inflammatory principles from green mussel *Perna viridis* L. and a product incorporating these ingredients	Provisional patent filed
2066/CHE/2010	2010	A product containing anti-inflammatory principles from green mussel *Perna viridis* L. and a process thereof	Provisional patent filed
2063/CHE/2010	2010	A process to prepare naturalised *Artemia francesciana* from indian subcontinent with high docosahexaenoic acid and trehalose for aquaculture applications	Provisional patent filed
2064/CHE/2010	2010	A process to prepare antioxidant and anti-inflammatory concentrates from brown and red seaweeds and a product therof	Provisional patent filed

Examination request filed for patents:

- Hatchery technology for production of clown fish 3455/DEL/05 dt 23.12.2005
- A phytase produced extracellularly from thermophilic bacterium 203/CHE/2009
- Commercialisation aspects of the potential technologies are being pursued by ITMU of CMFRI.

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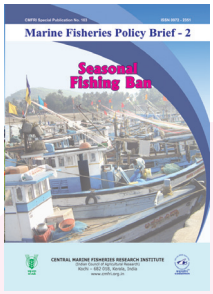

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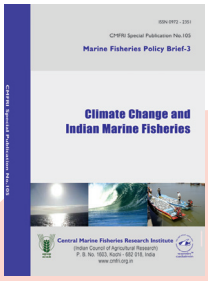

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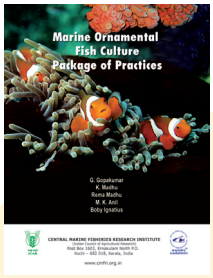

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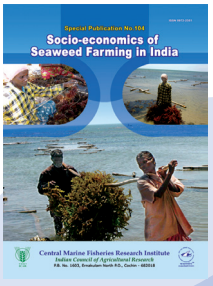

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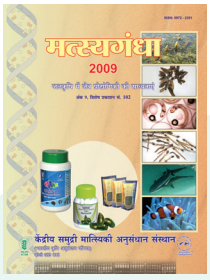

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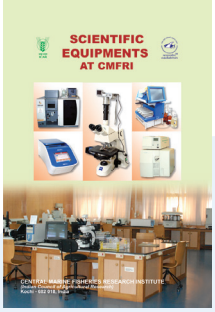

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Budget 2010 – 2011

The Budget and Expenditure under Non-Plan and Plan for the financial year 2010-2011 in respect of CMFRI (Figures in lakhs)

Budget head	Non-plan		Plan	
	Budget (Rs.)	Expenditure (Rs.)	Budget (Rs.)	Expenditure (Rs.)
Estt. Charges	3131.00	3131.00	0.00	0.00
Wages	0.00	0.00	0.00	0.00
OTA	0.50	0.50	0.00	0.00
TA	30.00	30.00	42.00	42.00
Other Charges	261.86	261.86	596.28	596.28
Information Technology	0.00	0.00	28.40	28.40
Capital	114.80	114.80		
Works	361.82	361.82	440.00	440.00
Other items including HRD			3.00	3.00
Total	**3899.98**	**3899.98**	**1109.68**	**1109.68**

Pension

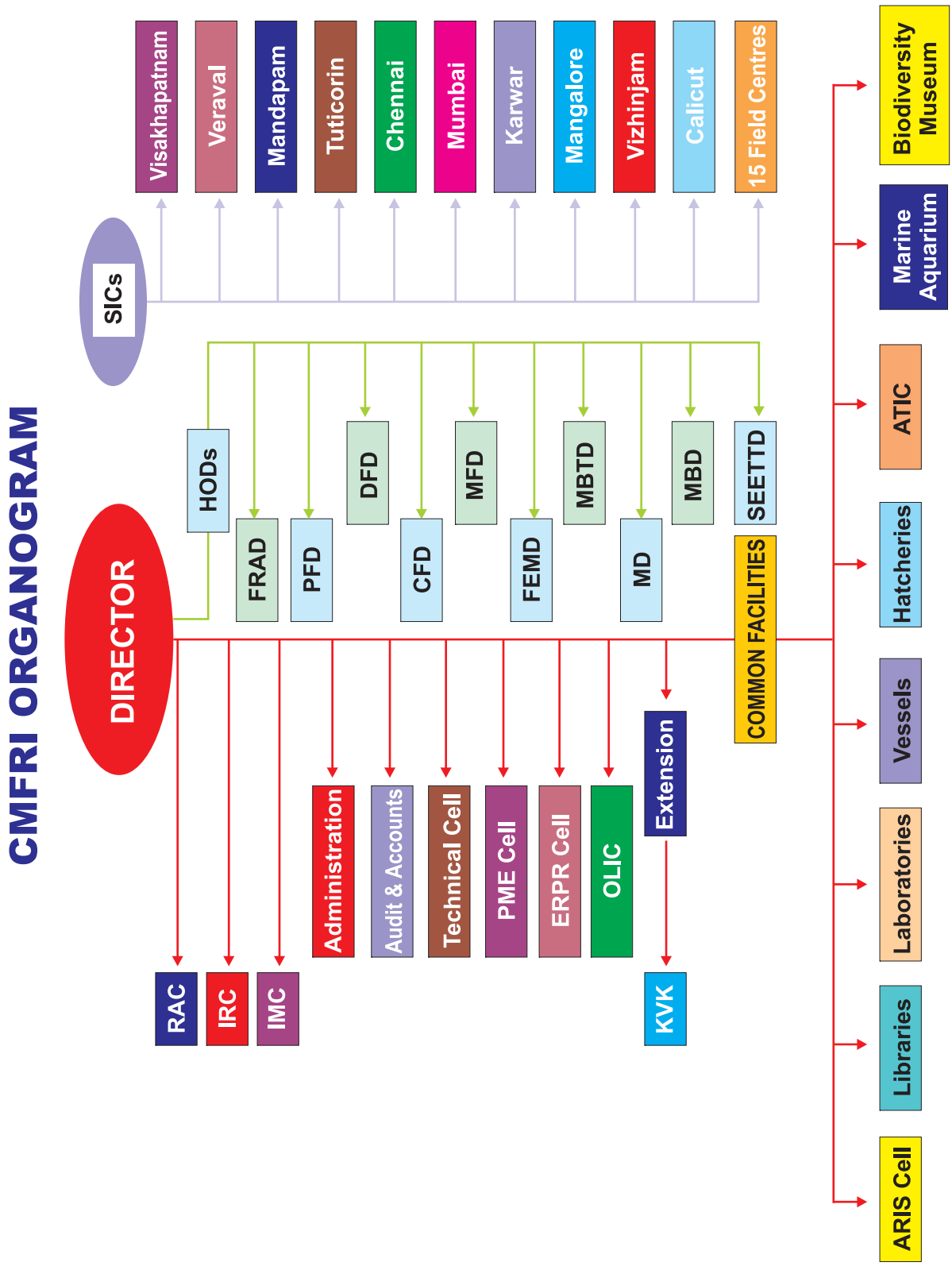
Budget head	Budget (Rs.)	Expenditure (Rs.)
Pension	2161.40	2161.40

Loans and Advances

Budget head	Budget (Rs.)	Expenditure (Rs.)
Loans and Advances	28.15	28.15

Other Projects

Budget head	Budget (Rs.)	Expenditure (Rs.)
Other non plan schemes		8.76
NAIP		454.71
Other plan schemes		38.44
Deposit schemes		274.36
A.P. Cess scheme		1.72
KVK, Narakkal		96.37
Consultancies		37.98
NICRA		272.41
Heads	**Target (Rs.)**	**Achievements (Rs.)**
Revenue receipts	63.00	79.57
Sale of assets	-	2.24
Interest on short term deposits	-	69.98
Recovery of loans and advances	-	52.36


CMFRI ORGANOGRAM
DIRECTOR
HODs
SICs
Visakhapatnam
Veraval
Mandapam
Tuticorin
Chennai
Mumbai
Karwar
Mangalore
Vizhinjam
Calicut
15 Field Centres
FRAD
PFD
DFD
CFD
MFD
FEMD
MBTD
MD
MBD
SEETTD
COMMON FACILITIES
RAC
IRC
IMC
Administration
Audit & Accounts
Technical Cell
PME Cell
ERPR Cell
OLIC
Extension
KVK
Biodiversity Museum
Marine Aquarium
ATIC
Hatcheries
Vessels
Laboratories
Libraries
ARIS Cell

Staff Strength and Managerial Positions as on 31.03.2011

Staff Strength as on 31st March 2011 including KVK, Narakkal

Name of Post	Sanctioned		In-position		Vacant
	CMFRI	KVK	CMFRI	KVK	
RMP	1	-	1	-	0
Scientific	173	1	110	-	64
Technical	303	11	271	9	34
Administrative	143	2	129	2	14
Supporting	238	2	178	2	60
Auxiliary	4	-	3	-	1
Total	862	16	692	13	173
	878		**705**		**173**

Managerial Positions

Director	**Dr. G. Syda Rao**
Heads of Divisions	
Crustacean Fisheries Division	Dr. E. V. Radhakrishnan
Marine Biodiversity Division	Dr. Mary K. Manisseri
Mariculture Division	Dr. G. Gopakumar
Fishery Environment Management Division	Dr. V. Kripa
Demersal Fisheries Division	Dr. P. U. Zacharia
Molluscan Fisheries Division	Dr. K. Sunil Kumar Mohamed
Marine Biotechnology Division	Dr. K. K. Vijayan
Pelagic Fisheries Division	Dr. Asokakumaran Unnithan (I/c)
Fishery Resources Assessment Division	Dr. T. V. Sathianandan (I/c)
Socio-Economic Evaluation and Technology Transfer Division	Dr. R. Narayanakumar (I/c)
Administrative Officer	Shri R. Anil Kumar
Sr. Finance and Accounts Officer	Shri. A.V. Joseph
Scientists-in-Charge of Regional/Research Centres	
Mandapam Camp	Dr. G. Gopakumar
Visakhapatnam	Dr. G. Maheswarudu
Veraval	Dr. R. Thangavelu
Chennai	Dr. E. Vivekanandan
Tuticorin	Dr. M. S. Madan
Karwar	Dr. K. K. Philippose
Mangalore	Dr. A. P. Dinesh Babu
Vizhinjam	Dr. Rani Mary George
Mumbai	Dr. V. D. Deshmukh
Calicut	Dr. P. Kaladharan
Krishi Vigyan Kendra, Narakkal	Dr. C. Ramachandran

Centre-wise List of Scientists

(as on 01.12.2010; not on seniority basis)

HEADQUARTERS, KOCHI

Sl. No.	Name	Designation
1.	Dr. E.V. Radhakrishnan	Principal Scientist
2.	Dr. (Mrs.) Mary K. Manissery	Principal Scientist
3.	Dr. P.C. Thomas	Principal Scientist
4.	Dr. T. S. Velayudhan	Principal Scientist
5.	Dr. Grace Mathew	Principal Scientist
6.	Dr. Sunil Kumar Mohamed	Principal Scientist
7.	Dr. (Mrs.) V. Kripa	Principal Scientist
8.	Dr. K.K. Vijayan	Principal Scientist
9.	Dr. P.U. Zacharia	Senior Scientist
10.	Dr. T.V. Sathianandan	Senior Scientist
11.	Dr. K. Asokakumaran Unnithan	Senior Scientist
12.	Dr. R. Narayanakumar	Senior Scientist
13.	Dr. E.M. Abdusamad	Senior Scientist
14.	Dr. P. Vijayagopal	Senior Scientist
15.	Dr. (Mrs.) D. Prema	Senior Scientist
16.	Dr. (Mrs.) Josileen Jose	Senior Scientist
17.	Dr. K.K. Joshi	Senior Scientist
18.	Dr. (Mrs.) Imelda Joseph	Senior Scientist
19.	Dr. K. Madhu	Senior Scientist
20.	Dr. (Mrs.) K.S. Sobhana	Senior Scientist
21.	Dr. (Mrs.) Shoji Joseph	Senior Scientist

Sl. No.	Name	Designation
22.	Dr. J. Jayasankar	Senior Scientist
23.	Dr. C. Ramachandran	Senior Scientist
24.	Dr. (Mrs.) Molly Varghese	Senior Scientist
25.	Dr. (Mrs.) Rema Madhu	Senior Scientist
26.	Dr. (Mrs.) Somi Kuriakose	Senior Scientist
27.	Dr. T.M. Najmudeen	Senior Scientist
28.	Dr. Shyam S. Salim	Senior Scientist
29.	Dr. V.P. Vipin Kumar	Senior Scientist
30.	Dr. Boby Ignatius	Senior Scientist
31.	Dr. R. Jeyabaskaran	Senior Scientist
32.	Smt. T.S. Naomi	Scientist
33.	Shri N.K. Sanil	Scientist
34.	Smt. U. Ganga	Scientist
35.	Smt. Rekha J. Nair	Scientist
36.	Dr. (Smt.) S. Lakshmi Pillai	Scientist
37.	Smt. Mini. K.G.	Scientist
38.	Dr. Kajal Chakraborty	Scientist
39.	Smt. Aswathy N.	Scientist
40.	Shri Wilson T. Mathew	Scientist
41.	Smt. Rekhadevi Chakraborty	Scientist
42.	Dr. Srinivasa Raghavan V.	Scientist

MANDAPAM REGIONAL CENTRE OF CMFRI, MANDAPAM CAMP

Sl. No.	Name	Designation
1.	Dr. G. Gopakumar	Principal Scientist
2.	Dr. V.S. Kakati	Principal Scientist
3.	Dr. K. Vinod	Senior Scientist
4.	Dr. I. Rajendran,	Senior Scientist
5.	Dr. A.K. Abdul Nazar	Senior Scientist
6.	Dr. M. Sakthivel	Scientist

Sl. No.	Name	Designation
7.	Shri V. Venkatesan	Scientist
8.	Miss Sandhya Sukumaran	Scientist
9.	Shri C. Kalidas	Scientist
10.	Shri G. Tamilmani	Scientist
11.	Shri Johnson B.	Scientist
12.	Dr. P. Rameshkumar	Scientist

VISAKHAPATNAM REGIONAL CENTRE OF CMFRI, VISAKHAPATNAM

Sl. No.	Name	Designation
1.	Dr. G. Maheswarudu	Principal Scientist
2.	Dr. P. Laxmilatha	Senior Scientist
3.	Dr. Shubhadeep Ghosh	Scientist
4.	Shri Ritesh Ranjan	Scientist

Sl. No.	Name	Designation
5.	Ms. Biji Xavier	Scientist
6.	Mrs. Muktha M.	Scientist
7.	Shri Loveson Edward L.	Scientist

VERAVAL REGIONAL CENTRE OF CMFRI, VERAVAL

Sl. No.	Name	Designation
1.	Dr. Gulshad Mohammed	Senior Scientist
2.	Dr. R. Thangavelu	Senior Scientist

Sl. No.	Name	Designation
3.	Shri Sreenath K.R.	Scientist
4.	Shri K. Mohammed Koya	Scientist

KARWAR RESEARCH CENTRE OF CMFRI, KARWAR

Sl. No.	Name	Designation
1.	Dr. K.K. Philipose	Senior Scientist
2.	Dr. S.R. Krupesha Sharma	Scientist
3.	Dr. Pradeep M.A.	Scientist
4.	Dr. Divu Damodaran	Scientist

TUTICORIN RESEARCH CENTRE OF CMFRI, TUTICORIN

Sl. No.	Name	Designation
1.	Dr. M.S. Madan	Principal Scientist
2.	Dr. I. Jagadis	Senior Scientist
3.	Dr. (Mrs.) C.P. Suja	Senior Scientist
4.	Dr. (Smt.) Asha. P.S.	Senior Scientist
5.	Dr. M. Sivadas	Scientist
6.	Dr. P.T. Sarada	Scientist
7.	Dr. E. Dhanwanthari	Scientist

MANGALORE RESEARCH CENTRE OF CMFRI, MANGALORE

Sl. No.	Name	Designation
1.	Dr. A.P. Dinesh Babu	Senior Scientist
2.	Dr. K. Vijayakumaran	Senior Scientist
3.	Dr. Pratibha Rohit	Senior Scientist
4.	Dr. (Smt.) Geetha Sasikumar	Scientist
5.	Dr. (Smt.) P.S. Swathilekshmi	Scientist
6.	Smt. Bindu Sulochanan	Scientist
7.	Shri Saravanan R.	Scientist
8.	Shri Purushottama G.B.	Scientist

MUMBAI RESEARCH CENTRE OF CMFRI, MUMBAI

Sl. No.	Name	Designation
1.	Dr. V.D. Deshmukh	Principal Scientist
2.	Dr. Veerendra Veer Singh	Principal Scientist
3.	Dr. (Smt.) Sujitha Thomas	Senior Scientist
4.	Shri Gyanaranjan Dash	Scientist
5.	Kum. Anulekshmi Chellappan	Scientist

VIZHINJAM RESEARCH CENTRE OF CMFRI, VIZHINJAM

Sl. No.	Name	Designation
1.	Dr. (Mrs.) Rani Mary George	Principal Scientist
2.	Dr. A.P. Lipton	Principal Scientist
3.	Dr. R. Sathiadhas	Principal Scientist
4.	Dr. N. Ramachandran	Principal Scientist
5.	Dr. M.K. Anil	Senior Scientist
6.	Dr. B. Santhosh	Senior Scientist
7.	Smt. S. Jasmine	Scientist
8.	Dr. K.N. Saleela	Scientist

MADRAS RESEARCH CENTRE OF CMFRI, CHENNAI

Sl. No.	Name	Designation
1.	Dr. G. Mohan Raj	Principal Scientist
2.	Dr. E. Vivekanandan	Principal Scientist
3.	Dr. Joe K. Kizhakudan	Senior Scientist
4.	Dr. (Mrs.) A. Margaret Muthu Rathinam	Senior Scientist
5.	Dr. (Ms.) Vidya Jayasankar	Senior Scientist
6.	Smt. Shoba Joe Kizhakudan	Scientist
7.	Mrs. P. Hemasankari	Scientist
8.	Dr. (Mrs.) R. Geetha	Scientist
9.	Dr. Sathianarayan Sethi	Scientist

CALICUT RESEARCH CENTRE OF CMFRI, CALICUT

Sl. No.	Name	Designation
1.	Dr. K.R. Manmadhan Nair	Principal Scientist
2.	Dr. P. Kaladharan	Principal Scientist
3.	Dr. P.K. Asokan	Senior Scientist
4.	Dr. P.P. Manoj Kumar	Senior Scientist
5.	Shri K.P. Said Koya	Scientist

PURI FIELD LABORATORY OF CMFRI, PURI (ORISSA)

Sl. No.	Name	Designation
1.	Dr. (Mrs.) Reeta Jayasankar	Principal Scientist

List of Projects

In-house projects

Sl. No.	Project Code	Name of the Project	Name of PI	Duration
Marine Capture Fisheries				
1.	FRA/ASSESS/01	Development of knowledge based information system for marine fisheries sustainability	Dr. T.V. Sathianandan	2007 - 2012
2.	FRA/ASSESS/02	Decision support system for marine fisheries management	Dr. J. Jayasankar	2007 - 2012
3.	FRAD/IDP/01	Sustainability profiling of Kerala coast using multi dimensional scaling approach	Dr. J. Jayasankar	2008 - 2010
4.	PEL/IDP/01	Management advisories for sustaining marine fisheries of Kerala and Lakshadweep	Dr. Said Koya	2007 - 2012
5.	PEL/IDP/02	Management advisories for sustaining marine fisheries for Karnataka & Goa	Dr. Prathiba Rohit	2007 - 2012
6.	CF/IDP/01	Management advisories for sustaining marine fisheries of Maharashtra	Dr.V.D. Deshmukh	2007 - 2012
7.	DEM/IDP/02	Management advisories for sustaining marine fisheries of Gujarat	Dr. R. Thangavelu	2007 - 2012
8.	DEM/IDP/01	Management advisories for sustaining marine fisheries of Tamil Nadu and Puducherry	Dr. E. Vivekanandan	2007 - 2012
9.	MF/IDP/01	Developing management advisories for sustaining marine fisheries of Andhra Pradesh	Dr. G. Maheswarudu	2007 - 2012
10.	PEL/IDP/03	Strategies for sustaining tuna fishery along the Indian coast	Dr. E.M. Abdussamad	2008 - 2012
11.	CF/RE/03	Dynamics of recruitment process of penaeid prawns along the Indian coast	Dr. V.D. Deshmukh	2007 - 2012
12.	CF/IDP/02	Resource damage assessment in marine fisheries: impact of selective fishing of juveniles and bycatch and discards in trawl fisheries	Dr. E.V. Radhakrishnan	2007 - 2012
13.	MF/IDP/02	Application of trophic modeling in marine fisheries management	Dr. K.S. Mohamed	2007 - 2012
14.	FEM/01	Impact of anthropogenic activities on coastal marine environment and fisheries	Dr. P. Kaladharan	2007 - 2012
15.	FEM/02	Impact and yield study of environmental changes on distribution shifts in small pelagics along the Indian coast	Dr. V. Kripa	2007 - 2012
16.	MD/IDP/01	Technology development for seed production of shellfish	Dr. Joe K. Kizhakudan	2007 - 2012
17.	MD/IDP/02	Technological upgradation of molluscan mariculture	Dr. P.K. Asokan	2007 - 2012
18.	MD/IDP/03	Development of broodstock, captive breeding and seed production techniques for selected marine food fishes and ornamental fishes	Dr. G. Gopakumar	2007 - 2012
19.	MD/IDP/04	Innovations of sea cage farming and development of sustainable Capture Based Aquaculture (CBA) systems	Dr. G. Syda Rao	2009 - 2011

Sl. No.	Project Code	Name of the Project	Name of PI	Duration
20.	MD/05	Conservation mariculture of selected species	Dr. I. Jagadis	2009 - 2011
21.	MBTD/NUT/01	Formulation and evaluation of larval and grow out feed for marine crabs, lobsters, ornamentals and cage farmed finfish	Dr. P. Vijayagopal	2007 - 2012
22.	MBTD/PATH/01	Pathogen profiling, diagnostics and health management in maricultured finfish and shellfish	Dr. K.K.Vijayan	2007 - 2012
23.	PNP/BIOT/02	Biotechnological applications in mariculture and conservation	Dr. P.C. Thomas	2009 - 2012
24.	MBD/RE/01	Understanding the threatened coral reef ecosystems of southern India and designing interventions aimed at their restorations	Dr. Mary K. Manisseri	2007 - 2012
25.	MBD/RE/04	Species variation and biodiversity of fishes of the family Lutjanidae in the Indian seas	Dr. K.K. Joshi	2007 - 2012
26.	MBD/RE/05	Assessment of biodiversity and ecological impact in open sea cage farming	Dr. K. Vinod	2008 - 2010
27.	SEE/PEM/01	Benefit cost assessment of marine fishery business and alternative investment options	Dr. R. Narayanakumar	2007 - 2012
28.	SEE/PMS/01	A diagnostic study on dimensions, causes and ameliorative strategies of poverty and marginalisation among the marine fisherfolk of India	Dr. C. Ramachandran	2007 - 2012
29.	SEE/PET/01	Impact of WTO regulations in Indian fisheries trade: a policy perspective	Dr. Shyam S.Salim	2009 - 2011
30	DEM/IDP/03	Carbon sequestration potential of Indian seaweeds	Dr. E. Vivekanandan	2010 - 2012
31	FEM/RE/03	Development of fisheries ecosystem restoration plans for critical marine habitats	Dr. V. Kripa	2010 - 2012
32	SEE/RE/05	Coastal rural indebtedness and impact of Micro Finance in Marine Fisheries Sector	Dr. Vipin Kumar V.P.	2010 - 2012
33	SEE/RE/04	Total factor productivity analysis of marine fisheries in India	Dr. N. Aswathy	2010 - 2012

Sponsored projects

S.No.	Title of the Project	Name of the Funding Agency	Date of start	Duration
1.	Farming and pearl production in the black lip pearl oyster *Pinctada margaritifera.* PI: Dr. K. S. Mohamed	MoES/CMLRE	2008	2003-2007 (Extension upto 2012)
2	Open sea floating cage farm for R&D in marine finfish and shellfish production. PI: Dr. G. Syda Rao	MoA (DAHD&F)	23, September 2005	2005-2008 (Extension upto 2011)
3	Seed production in agricultural crops and fisheries. PI: Dr. K. Madhu	ICAR	2005	2006 – 2010 Project will continue in the XI plan
4	Application of micro organisms in agriculture and allied sectors (AMAAS): Microbial diversity and identification – fish microbes. PI: Dr. Imelda Joseph	ICAR Network (NBAIM-Mau)	April, 2006	2006 – 2010 (Extension upto 2011)
5	Development of genetically improved strains of brine shrimp *Artemia* using quantitative and molecular genetic tools. PI : Dr. P. C. Thomas	DBT	September, 2007	2007-2010

S.No.	Title of the Project	Name of the funding Agency	Date of start	Duration
6	Development of species specific DNA markers in economically important shellfish species green mussel (*Perna viridis*) and edible oyster (*Crassostrea madrasensis*) for their application in farming and resource management. PI : Dr. K. K. Vijayan	DBT	December, 2007	2007-2010
7	Assessment of myctophid resources in the Arabian Sea and development of harvest and post harvest technologies. PI: Dr. E. M. Abdussamad	MoES/CMLRE	March, 2008	2007-2012
8	Impact, adaptation and vulnerability of Indian agriculture to climate change (II phase). PI: Dr. E. Vivekanandan	ICAR Network	April, 2007	2007- 2012
9	Demonstration and transfer of technology of marine pearl culture *Pinctada fucata* PI: Dr. I. Jagadis	MoES, CMLRE	February, 2008	2007-2012
10	Fast track scheme: Characterization of novel antioxidants from red and brown seaweeds from Gulf of Mannar PI: Dr. Kajal Chakraborty	DST	March, 2008	2007-2012
11	Open sea cage culture demonstration farms in India. PI: Dr. G. Syda Rao	NFDB	2008	2008 – 2010
12	Application of microorganisms in agriculture and allied Sectors (AMAAS): Development of a library putative probionts from marine environment belonging to the genus *Pseudomonas*, *Micrococcus* and *Bacillus* for application in mariculture systems PI: Dr. K. K. Vijayan	ICAR Network (NBAIM-Mau)	December, 2008	2008 – 2010
13	Establishment and chararacterization of cell lines from selected marine food fish and ornamental fish PI: Dr. K. S. Sobhana	DBT	July, 2008	2008 – 2011
14	Development of shallow water grow-out techniques for the venerid clam, *Paphia malabarica* (Chemnitz) and the corbiculid clam, *Villorita cyprinoides* (Grey) PI: Dr. N. Suja DST- women scheme	DST	December, 2010	2008 - 2011
15	Assessment of fishery resources along the Indian continental slope and Central Indian Ocean PI: Dr. U. Ganga	MoESC/MLRE	April, 2008	2007– 2012
16	Studies on marine mammals of Indian Exclusive Economic Zone and the contiguous seas (II phase) PI: Dr. E. Vivekanandan	MoES/CMLRE	April, 20070	2007 – 2012
17	Bioinventorisation of coral fishes of South India with special reference to threats and conservation measures PI: Smt. Rekha J. Nair	MoEF	July, 2009	2009 – 2012
18	An assessment of literacy, income and health status of fishers in India. PI: Dr. R. Sathiadhas	MoA (DAHD&F)	November, 2009	2009 – 2010
19	ICAR outreach activity on fish genetic stocks PI: Dr. P. C. Thomas	ICAR Outreach	November, 2008	2008 – 2012
20	ICAR outreach activity on fish feeds PI: Dr. P. Vijayagopal	ICAR Outreach	2008-09	2008 – 2012
21	ICAR outreach activity on nutrient profiling and evaluation of fish as a dietary component PI: Dr. Kajal Chakraborty	ICAR Outreach	2008-09	2008 – 2012
22	Evaluation and development of green water technology for bioremediation in coastal aquaculture Co-PI: Dr. Reeta Jayasankar	DBT	July, 2008	2008 – 2011

S.No.	Title of the Project	Name of the funding Agency	Date of start	Duration
23	Establishment of four artificial reefs by fishermen on participatory mode along Tamil Nadu coasts for marine fishery resource enhancement (with the involvement of NGO, PLANT). PI : Dr. G. Mohanraj	TNFD	November, 2009	2008-2010
24	Development of cage of mariculture through numerical and physical modeling. Co-PI: Dr. G. Syda Rao	MoES	June, 2010	2010-2012
25	EFC Memo Project Implementation Committee of DARE for the XI Plan (2007-12) Government of India National Initiative on Climate Resilient Agriculture (NICRA) – Marine Fisheries. CPI: Dr. E. Vivekanandan	MoA	February, 2011	2011-20121
26	Development of tuna fishery forecast system (TUFFS) CPI: Dr. Prathibha Rohit	INCOIS	February, 2011	2011- 2012
27	Utilization strategy for oceanic squids (Cephalopoda) in Arabian Sea: A value chain approach. CPI: Dr. K.S. Mohamed	World Bank NAIP	February, 2009	2009 - 2012
28	A value chain on high value shellfishes from mariculture systems. CPI: Dr. T.S. Velayudhan	World Bank NAIP	February, 2009	2009 – 2012
29	Export oriented marine value chain for farmed sea food production using Cobia through rural entrepreneurship. CCPI: Dr. G. Gopakumar	NAIP	September, 2009	2009 - 2012
30	Bio-prospecting of genes and allele mining for abiotic stress tolerance. CCPI: Dr. K. K. Vijayan	NAIP	September, 2009	2009 - 2012
31	Strategies to enhance adaptive capacity to climate change in vulnerable regions. CCPI: Dr. V.V. Singh	World Bank - GEF NAIP	September, 2009	2009 – 2013
32	Developing, Commissioning, Operating and Managing Online System for NET/ARS- Prelim Examinations by ASRB/ICAR. CCPI: Dr. G. Syda Rao	NAIP	July, 2010	2010 - 2012
33	A value chain on oceanic tuna fisheries years in Lakshadweep Sea. CPI: Dr. E.V. Radhakrishnan	NAIP	April, 2008	2008 – 2012

Consultancy projects

Sl. No.	Title	Client
1	Planning, construction management of Sweet, Brackish & Marine aquariums	Surat Municipal Corporation Surat,Gujarat
2	An assessment of fish production and likely financial losses to fishers due to development of Rewas-Aware Port	M/s. Maharashtra Maritime Board, Indian Mercantile Chambers, R. K. Marg, Ballard Estate, Mumbai-400 038
3	Impact of development of a jetty at Killa bunder on fishing activities in Vasai Creek	Maharashtra Maritime Board, Indian Mercantile Chambers, R. K. Marg,Ballard Estate, Mumbai-400 038
4	Installation of water purification and life support systems, ecosystem development and live stock malignance in the Marine aquarium at Surat (Phase-II)	Surat Municipal Corporation, Surat,Gujarat

Sl. No.	Title	Client
5	Installation of artificial reef to enhance biological resources and livelihood of fishermen	M/s. Chennai Water Desalination ltd, Guindy, Chennai-600032
6	Monitoring chemical parameters of effluent and the hydrrobiological conditions in the Arabian Sea off Chitrapur (Phase-10)	M/s.MRPL,Mangalore
7	Advisory on screening of OIE listed pathogens relevant to Kerala, India.	M/s.KVIL,1, Salim Ali Road, EKM. NorthKochi-602018.
8	Breeding Technology of *Amphiprion ocellaris*	M/s Abad Hatchery, Kandakadav, Kandakadavu P.O,Chellanam, EKM.
9	Whale Shark Conservation	Executive Director, Wild Life Trust of India B-13, 2nd Floor, Sector VI, NOIDA, UP
10	Consensus Building and Environmental Studies on Marine Outfall for Mumbai Sewage Disposal Project (MSDP) Phase II	Mott Mac Donald Pvt. Ltd (MMPL), 7th FloorA-Wing Prism Tower, Mindspace, Goregaon
11	Rapid Environmental Impact Assessment Study	Dr.A.L. Muthuraman Joint Director (Aqua),MPEDA, Kochi
12	Impact assessment of multipurpose reef at Howa Beach, Kovalam, Thiruvananthapuram on fishery resources of the area	The Director, Dept. of Tourism, Park Avenue,Thiruvananthapuram
13	Monitoring chemical parameters of effluent and the hydrobiological conditions in the Arabian sea off Chitrapur ….(Phase-11)	M/s.MRPL,Mangalore
14	Study on the use of Fly ash for manufacture of Artificial Reefs	Deputy Manager (AUD), NTPC, Simhadri Thermal Power Plant, Visakhapatnam
15	Setting up of modern library at RGCA, Sirkali	Project Director, RGCA, Sirkali, TN
16	Baseline data collection and monitoring for environment and social impact assessment for the development of Vizhinjam port	M/S Asian Consulting Engineers, New Delhi

Human Resource Development and Women Cell

Training category	No. of trainings/ workshops	Number of persons trained
Trainings at CMFRI for outside participants	8	305
Training conducted by CMFRI for its personnel	8	210
Training to CMFRI staff at other Institutes	18	29
Total	**34**	**544**

1. Training programmes for which CMFRI staff were deputed

Sl.No	Training course	Period	Location/ Nodal Division	No. of participants
1	Fishery Resources Management	22 March - 11 Apr., 2010	CIFE, Mumbai	1
2	SAS Usage	12 July, 2010 - 13 Aug., 2010	CIFE, Mumbai	2
3	Establishment Rules	10-14 May, 2010	ISTM, New Delhi	1
4	Technology Forecasting Methodologies	13-17 July, 2010	IASRI, New Delhi	1
5	IT based Decision support systems for Digital content Development	5-15 Oct., 2010	NAARM, Hyderabad	1
6	Project cycle management (RTC-2)	4 -10 Oct., 2010	IUCN, India, Chennai Centre	1
7	Sensitization-cum- Project Information & Management System of ICAR.	25 Oct., 2010	by IASRI, New Delhi at NAARM, Hyderabad	1
8	Market-led Extension for KVK staff	21-25 June, 2010	MANAGE, Hyderabad	1
9	Soil/Water/Plant analysis for KVK staff	June, 2010	CPCRI, Kasargod	2
10	MDP on Data mixing and GIS for Decision support in Agriculture	10-22 Jan., 2011	NAARM, Hyderabad	5
11	Leadership for innovations in Agriculture	21-25 Feb., 2011	IIM, Lucknow	1
12	Molecular diagnostics and fingerprinting of salmonella and pathogenic vibrios with sea food and aquatic.	14-27 Feb., 2011	CIFT, Kochi-29	1
13	Establishment of National Agricultural Bio-informatic Grid in ICAR	24 - 28 Jan. 2011	NBFGR, Lucknow	1
14	Institutional change for inclusive Agriculture growth.	15 Feb. - 7 March, 2011	IARI, New Delhi	1
15	MDP on date Mining and GIS for Decision support in Agriculture	28 March - 8 April, 2011	NAARM, Hyderabad	1
16	Mobilizing mass media support for sharing Agro information	28 Feb. - 4 March, 2011	IIMC, New Delhi	1

Sl.No	Training course	Period	Location/ Nodal Division	No. of participants
17	Data analysis using SAS Under NAIP Project on SSC for NARS	3 - 9 March, 2011	CTCRI, Trivandrum	5
18	Current approaches ad Applications of Bioinformatics in Agriculture Research	28 March - 6 April, 2011	CTCRI, Trivandrum	2

2. Trainings conducted at CMFRI with outside participation

Sl.No	Training course	Period	Location/ Nodal Division	No. of participants
1	Marine Ornamental Fish Culture	15 - 24 July, 2010	Vizhinjam R.C. of CMFRI	20
2	Sea cage farming of seabass and lobsters	27 Oct. 2 Nov., 2010	Vizhinjam R.C. of CMFRI.	24
3	Marine Ornamental Fish Culture	6-15 Dec., 2010	CMFRI Regional Centre, Mandapam.	20
4	Cage Farming of Marine Finfish and Shellfish at Karwar RC of CMFRI.	7-16 March, 2010	Karwar R.C. of CMFRI, Karwar	18
5	Green mussel farming at Calicut RC of CMFRI.	10-19 Feb., 2011	Calicut R.C. of CMFRI	18
6	Winter school on "Vistas in Marine Biotechnology"	5-26 Oct., 2010	CMFRI, Kochi by MBTD	25
7	Responsible fishing/fish processing for fishermen and processing workers.	25 June, 2010	Narakkalunder KVK	140
8	Tuna processing and value addition	4 March, 2011	Kavaratti (Lakshadweep) under NAIP	40

3. Trainings for CMFRI staff conducted at the Institute

Sl.No	Training course	Period	Location/ Nodal Division	No. of participants
1	Orientation Course for new Scientists	1-15 June, 2010	CMFRI,Kochi by HRD Cell	11
2	Fish landing data collection methodology and fish identification	19-24 July, 2010	CMFRI, Kochi by CFD	10
3	Performance Management for CMFRI Staff	3 Aug., 2010	CMFRI, Kochi by HRD Cell	40
4	Computer Training for CMFRI Staff.	1 July, 2010 to 22 July, 2010	CMFRI, Kochi by HRD Cell	31
5	Emotional Intelligence at Work Place for CMFRI	9 Nov., 2010	CMFRI, Kochi by HRD Cell	41

Sl.No	Training course	Period	Location/ Nodal Division	No. of participants
6	Prawn Taxonomy: recent advances and revision of nomenclature Workshop	14-19 Feb,. 2011	CMFRI, Kochi by CFD	35
7	SAS statistical software	21-22 March, 2011	CMFRI, Kochi by FRAD	19
8	Analytical Methods in Fish Stock Assessment with special emphasis on tuna and tuna like resources	7-11 March 2011	CMFRI, Kochi by CFD	23

4. Ph. D Programme during 2010-11

Doctoral research of the 33 existing Research fellows under CUSAT, Cochin and Mangalore University are progressing satisfactorily. Four Research fellows have newly registered for Ph.D programme during 2010-11 and their research work is in progress. Two scholars have been awarded Ph.D. degree during 2010-11. One scholar has submitted the thesis for adjudication during 2010-11.

Women Cell

The Women Cell, organized a special talk cum interactive session on the theme "*Management of Age Related Health Challenges"* by Dr. Rajkumari Unnithan, DGO, MD, FICS, Senior Consultant in Gynaecology, Sunrise Institute of Medical Sciences (Superspeciality Centre), Kakkanad, Ernakulam on 23rd March, 2011 in the CMFRI Auditorium. Presidential address was given by Dr. G. Syda Rao, Director, CMFRI. Scientists, technical, administrative staff, research scholars and students of CMFRI, NBFGR and CIFRI attended the programme and participated in the lively interactions which focused mainly on the varied aspects of health challenges faced by the present day women, both the young and the elderly alike and the importance of timely interventions of remedial measures in exigencies.

Dr. Rajkumari Unnithan, DGO, MD, FICS, Senior Consultant in Gynaecology, addressing the audience

As a preliminary step in health care plan a demonstration cum training session was imparted to lady volunteers of CMFRI to check blood pressure, under the supervision of Dr. V. P. Vipinkumar, Senior Scientist during October, 2010. The trained volunteers would take turns to check the blood pressure of the needy lady staff members as and when needed.

Programmes Organised

Institute Management Committee (IMC)

The 71st IMC meeting was held on 26.03.2011 at CMRI - Headquarters. Review of action taken on the items considered during the previous meeting held on 20.03.2010 at CMFRI, Kochi (70th IMC) was done. As per the proposal submitted to the IMC of CMFRI for nomination of members to the Institute Grievance Committee, the Grievance Committee of CMFRI has been re-constituted. The proposal for recognition of Lakeshore Hospital and Kottakkal Arya Vaidya Sala for availing allopathic/ayurvedic treatment has already been sent to the Council for approval. On the basis of the recommendation of the IMC, the Council has approved the expenditure incurred on security service of CMFRI. Council's policy decision is required to entrust the security to CISF. Expenditure of the amount allotted under Plan and Non-Plan 'Works' for the financial year 2009-10 was reviewed. Expenditure on various maintenance works at Headquarters and Regional/Research Centres under Plan and Non-Plan 'Works' for the financial year 2010-11 was also reviewed.

Research Advisory Committee (RAC)

The 15th Research Advisory Committee meeting of CMFRI was held in CMFRI, Kochi on 28th February and 1st March 2011. The meeting was chaired by Dr. M.V. Gupta, World Food Prize Laureate and former Assistant Director General, WorldFish Center. Dr. E.V. Radhakrishnan, Director-in-Charge, made a comprehensive presentation on the progress made by the Institute during 2010-11. This was followed by presentations by all the Heads of Divisions. The Chairman and members commended the progress and made suggestions for improving the research activities of CMFRI. The following recommendations were made by the RAC:

1. The 15th RAC reiterates the recommendation of 14th RAC that CMFRI / ICAR should continue their efforts to get fisheries data collected by CMFRI recognized as the official fisheries statistics of the country.
2. CMFRI may include valuation and costing of fragile marine ecosystems as one of the priority research areas for the 12th plan period.
3. Impact of seaweed farming on the habitats may be investigated in Gulf of Mannar and Palk Bay.
4. Expertise and facility may be established to geo reference fisheries data by following standards on spatial and non - spatial database.
5. Capacity building in frontier areas such as modeling, geoinformatics and hatchery seed production is required for the scientists.
6. A review of the impact and benefits to the communities by CMFRI research and technologies be undertaken. A mechanism may be developed for better dissemination of technologies developed by the Institute.
7. The Institute may hold consultative workshops with stakeholders for advocating marine fisheries policy brief for each maritime state.
8. CMFRI/ICAR may continue its efforts to commercialise Green Mussel Extract and ornamental fish feed developed by the Institute.
9. The valuable historic data available with CMFRI may be digitized at the earliest for further analysis.
10. Breeding, seed production and larviculture techniques of cultivable food fish such as Cobia should be standardised at the earliest.
11. Research on characterisation of functional genes involved in stress tolerance may be strengthened.

Institute Research Council (IRC)

The 17th Institute Research Council (IRC) meeting of CMFRI was held at CMFRI Headquarters, Cochin during 28-30 June, 2010. The meeting was chaired by Dr. G. Syda Rao, Director. After the introductory remarks by the Chairman, minutes of the previous IRC was approved by the august body. The actions taken on the items considered during the 16th IRC were then reviewed. The Heads of Divisions, Principal Investigators and individual scientists presented achievements of the research conducted in 30 in-house projects during the period 2009-10. This was followed by critical evaluation and fruitful discussions. Three new projects were proposed and these were approved with modifications. The Director appreciated the keen interest and dedicated efforts taken by the scientists of CMFRI. The 17th IRC came to an end at 1700 hrs on 30th June 2010.

Workshops

National workshop on Open Sea Cage Farming jointly organised by NFDB and CMFRI at Karwar Research Centre of CMFRI during 17-18 July, 2010.

Workshop on "Bycatch: Its impact on marine fisheries" at Mangalore on 18 August, 2010.

Workshop on Climate Resilient Agriculture: Action Plan of the project on NICRA- Marine Fisheries at CMFRI, Cochin during February 4 - 5, 2011.

Workshop on "Taxonomy and Biodiversity of the fishes of the family Lutjanidae" at CMFRI, Cochin during 8-11 February, 2011.

Workshop on "Prawn Taxonomy: Recent advances and revision of nomenclature" at CMFRI, Cochin, during 14 - 19 February, 2011.

Workshop on Business opportunities in oyster cuisine jointly organized by CMFRI & CGH group of hotels at Fort Kochi on 23 February, 2011.

Workshop on data collection related to spawning behaviour of marine fish species to change in temperature at CMFRI, Cochin on 24 March, 2011.

Workshop on Tuna processing and value addition under the NAIP project 'A value chain on oceanic tuna fisheries in Lakshadweep sea' was jointly organized by CMFRI, CIFT and Department of Fisheries, Lakshadweep at Kavaratti, UT of Lakshadweep on 4th March, 2011.

Workshop on "Analytical methods in fish stock assessment with special emphasis on tuna and tuna like resources" at CMFRI, Cochin during 7-11 March, 2011.

Workshop on Marine mammal conservation and fisheries management at Karwar on 9 March, 2011.

Workshop in 'Climate Change on Indian Marine Fisheries' under the ICAR Network Project at Kovalam on 25th March 2011.

Training Programmes

Training in Remotely Operated Vehicle under NAIP project at CMFRI, Kochi during 11-13 May, 2010.

Training programme in Farming, purification and nutritional qualities of oysters, jointly organized by CMFRI & CGH group of hotels at Fort Kochi on 17 June, 2010.

Training in Value added product development jointly organized by CMFRI and NIFPHAT at Moothakunnam on 30 November, 2010.

Training to use modified Pablo boat for squid jigging under NAIP project at Agatti during 29 December 2010 - 01 January, 2011.

Training in Remote setting and oyster spat rearing under NAIP project at Moothakunnam on 24 January, 2011.

Training in Mussel and Oyster farming at Chettuva on 26 February, 2011.

Winter School on "Vistas in Marine Biotechnology" at CMFRI, Kochi during 5-26 October, 2010.

Training in Marine pearl culture at Tuticorin Research Centre of CMFRI during 17 - 29 May, 2010.

A hands on training programme on Bivalve hatchery and mariculture at Tuticorin RC of CMFRI during 5 - 13 August, 2010.

Training programmes on 'Spherical nucleus implantation' under the project 'Demonstration and transfer of technology of pearl culture' at Sippikulam Village, Tuticorin during 3 - 13 September, 2010 and 25 January, 2011 to 5 February, 2011.

Training programme on Fish landing data collection methodology and fish identification to skilled workers appointed at Lakshadweep at CMFRI, Cochin during 19 - 24 July, 2010.

National Training on Marine Ornamental Fish Culture sponsored by National Fisheries Development Board (NFDB), Hyderabad at Mandapam Regional Centre of CMFRI during 6-15 December, 2010.

Training programme on Marine Ornamental Fish Culture at Vizhinjam Research Centre of CMFRI, fduring 15 - 24 July, 2010.

National Training on Sea Cage Farming of Seabass and Lobsters organized in collaboration with NFDB at Vizhinjam Research Centre of CMFRI during 27 October - 2 November, 2010.

Training programme on 'Familiarization of cage culture techniques on seabass' for fishermen leaders and fish farmer entrepreneurs of Matsysfed, Kasargod, on 7, August, 2010.

Training on Green mussel farming sponsored by NFDB at Calicut RC of CMFRI during 10 - 19 January, 2011.

Training programme on "Open sea cage culture of marine finfish and shellfish" at Karwar RC of CMFRI during 7 - 16 March, 2011.

Events

Video film (DVD) on "New Horizons in Mariculture – Lobster Culture in Cages" prepared by CMFRI was released by Dr. S.Ayyappan, Director General, ICAR in New Delhi on 23 May, 2010.

DVD on on "New Horizons in Mariculture –"Culture of seabass in open sea cages" released by Dr. P. Krishniah, IAS, Chief Executive NFDB, Hyderbad at Karwar on 18 July, 2010.

The logo of the 9th Indian Fisheries Forum unveiled by Dr. E. G. Silas, fromer Vice-chancellor, Kerala Agricultural University and the website of the 9thiff www.9iff.org launched by Ms. Leena Nair, IAS, Chairperson, MPEDA at CMFRI, Kochi on 19 November, 2010.

The Open Access Institutional Digital Repository, 'eprints@cmfri' launched by Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR at CMFRI, Kochi on 26 November, 2010.

Soil and Water Analysis Laboratory of Krishi Vigyan Kendra inaugurated by Dr. S.Ayyappan, Director General, ICAR, at Residential Complex of CMFRI, Thevara on 26 November, 2010.

A programme on "Biodiversity in India with special reference to corals" was telecast live in Doordarshan Malayalam Channel on 25 February, 2011.

CMFRI initiated programme on Community based Marine Ecosystem Restoration in Kerala launched on the World Environment Day at Moothakunnam on 5 June, 2010.

The World Oceans Day with the theme "Our oceans: Opportunities and Challenges" celebrated at Mangalore RC of CMFRI, Mangalore on 8 June, 2010.

The mid-term review mission of the World Bank visited CMFRI to review the progress of the NAIP funded projects (component 1-4) in the Kerala region during 23 - 24 May, 2010.

Harvest Mela of seabass conducted in the presence of the Chief Guest Thiru K. P. P. Samy, Hon'ble Minister for Fisheries, Tamil Nadu State at Chemmencherry, Chennai on 3 August, 2010.

Seabass harvest festival jointly organized by CMFRI and NFDB inaugurated by Shri. Anand V. Asnotikar, Hon'ble Minister for Fisheries, Govt. of Karnataka at Baithkol Fishing Harbour, Karwar on 17 July, 2010.

Harvest mela of Malabar red snapper at Calicut Research Centre of CMFRI on 8 February, 2011.

Participation in Exhibitions

Colloquium on R&D Industry Interface for Biotechnology Development, Kerala at IMA Hall, Kochi on 12 January, 2011.

Asian-Pacific Aquaculture-2011 at Le Meridian Hotel, Kochi during 17 - 20 January, 2011.

Aqua Show 2010-11 organised by MATSYAFED at Kanakakunnu Palace, Thiruvananthapuram, Kerala during 7 - 16 January, 2011.

First Indian Biodiversity Congress, IBC 2010, at Thiruvananthapuram, Kerala during 28 - 30 December, 2010.

National Exhibition (Fish Fest) by the Kerala State Fisheries Department at Thiruvananthapuram during 24 - 28 February, 2011.

Rural Technology Mela at National Institute of Rural Development at Hyderabad during 2 - 5 February, 2011.

Science Festival conducted by Periyar Science City, Anna University, Chennai during 29 January - 2 February, 2011.

AQUA-AQUARIA - 2011 organised by MPEDA at Chennai Trade Centre during 6 - 8 February, 2011.

MAHAFISH Festival "Matsyagandha' organized by Maharashtra State Fisheries Department & Maharashtra Fisheries Development Corporation at Bandra Kurla Complex, Mumbai from 26 - 28 December, 2010.

Matsya Mela-2011 by the Dept. of Fisheries, Govt. of Karnataka and NFDB, Hyderabad at Palace Grounds, Bangalore during 18 - 21 February, 2011.

INFISH 2010 Exhibition at Hyderabad organised by NFDB during 9 - 12 July, 2010.

Kalpakam - 2010 Exhibition organized by KVK Alleppey of CPCRI Kayamkulam during 1 - 4 September, 2010.

Exposition entitled '*Krishidarpan*' at *Rajendra Maidan*, Kochi during 11 - 12 March, 2010.

Innovation-4 Industry Meet exposition of entrepreneur ready technologies of CMFRI at Visakhapatnam on 8 September, 2010.

'*Theersasthrotsav*' exposition organised by Coastal Educational Society, Alleppey held at Mararikkulam during 18 - 20 November, 2010.

Exhibition Public information campaign organized by the PBI, Cochin at Poilkavu, Calicut during 24 - 26 December, 2010.

Agricultural Technology exhibition and "Kisan Mela" at IISR Calicut during 27 - 29 January, 2011.

Library and Documentation

The modernised library of CMFRI facilitates the use of print, electronic and digital library resources in a user-friendly manner. During the year, the Institute subscribed 71 national and international journals including online versions and new ASFA Online Database which covers records from 1971 onwards. The subscribed IP based online versions are made available to Regional and Research Centres of CMFRI. More than 500 International open access journals on marine fisheries are made available through digital library in the CMFRI website.

Information services provided

1. **OPAC** - Online Public Access Catalogue (OPAC) can be accessed globally from CMFRI website. It allows users to search for the bibliographic records and details of books, journals, current periodicals, reports, proceedings, theses & other publications available in the library.
2. Computerised circulation of books & journals continued to the members of library, using Barcoded Library Identity Card .
3. **Digital Library** - CMFRI Digital Library System houses all electronic publications and information available in the Library. It provides access to Databases, CD-ROMs, Electronic Journals, holdings of journals, current periodicals, CMFRI Theses and Dissertations and other CMFRI Publications.
4. **Access to CERA** - CMFRI can access more than 3000 electronic journals on agriculture and allied subjects through Consortium for e-Resources in Agriculture, the project under NAIP, ICAR through the website www.cera.jccc.in.
5. **Online Document Delivery Service (ODDS)**- provides the latest information in the field of marine research and fisheries. The ODDS is delivered to all the scientists individually by email.
6. **Current Awareness Service:** ' Current Awareness Service' the monthly publication issued from library is digitised and made available on CMFRI website.
7. **Exchange of Institute Publications**: The library maintained the 'exchange relationship' with various National and International research Institutes, universities and other organizations by sending Institute publications and receives 400 titles of journals in exchange/complementary basis.
8. **Launching of eprints@cmfri – A digital Institute repository**

The Open Access Institutional Repository 'eprints@CMFRI' was launched by Dr. S. Ayyappan, Secretary, DARE and Director General , ICAR on 26th November 2010. The repository is the digital archive of all scientific publications by the Institute staff members. The repository can be accessed from the Institute website. At present 9000 scientific papers are uploaded. The metadata of the repository is made available to search engines like Google, Google Scholar, OAlister, Base, Scientific Common and Scirus. This Repository is listed in the Registry of Open Access Repository, UK, Open DOAR (Directory of Open Access Repository) , UK and Avano OAI harvester.

CMFRI Publications released during 2010-11

1. Indian Journal of Fisheries:
   Vol. 57, Nos. 1-4, 2010
2. Marine Fisheries Information Service :
   Nos. 201 to 204
3. Newsletter Nos. 124 to 127
4. Special Publication Nos. 101 to 104
5. Annual Report: 2009-10

Launching of eprints@cmfri by Dr. S. Ayyappan, Secretary, DARE & Director General of ICAR on 26-11-2010

CMFRI Biodiversity Museum

(Designated National Repository)

The Designated National Repository Museum of CMFRI, recognized by the Government of India is authorized to keep in safe custody specimens of different categories of biological material. Currently the museum houses specimens of about 1,600 species, belonging to different groups of marine organisms.

New additions to the National Repository

Seaweeds

1. *Cladophora lehmanniana* (Lind.) Kuetz.
2. *Sargassum vulgare* C.Ag.
3. *Chondria cornuta* Borges.

Shrimp

1. *Lysmata amboinensis* De Man, 1888

Crabs

1. *Stilbognathus curvirostris* (A. Milne-Edwards, 1865)
2. *Enoplolambrus echinatus* (Herbst, 1790)
3. *Camposcia retusa* Latreille, 1829
4. *Halimede ochtodes* (Herbst, 1783)
5. *Eucrate crenata* (De Haan, 1835
6. *Lauridromia dehaani* (Rathbun, 1923)
7. *Carpilius maculatus* (Linnaeus, 1758)
8. *Doclea ovis* (Fabricius, 1787)
9. *Plagusia squamosa* (Herbst, 1790)
10. *Rhinolambrus contrarius* (Herbst, 1804)
11. *Chasmocarcinops gelasimoides* Alcock, 1900
12. *Schizophrys aspera* (H.Milne Edwards, 1834)
13. *Percnon planissimum* (Herbst, 1804)
14. *Carpilius convexus* (Forskal, 1775)
15. *Coleusia palkensis* sp.nov.(Kakati & Galil, 2011)
16. *Aethra scruposa* (Linnaeus, 1764)
17. *Demania baccalipes* (Alcock, 1898)
18. *Ocypode ceratophthalmus* (Pallas,1772)
19. *Atergatis subdentatus* Dehaan 1835
20. *Calappa capellonis* Laurie, 1906
21. *Ryphila cancellus* (Herbst, 1783)
22. *Prismatopus aculeatus* (H. Milne Edwards,1834)

Echinoderm

1. *Pentaceraster mammillatus* (Audouin, 1826)

Fishes

1. *Rhinopias eschmeyeri* Conde', 1977
2. *Lates calcarifer* (Bloch, 1790)
3. *Rhincodon typus* Smith, 1828
4. *Xiphias gladius* Linnaeus, 1758
5. *Neoharriota pinnata* Schnakenbeck, 1931
6. *Opistognathus nigromarginatus* Rüppell, 1830
7. *Pseudanthias pillai*(sp. nov)
8. *Halaelurus quagga* (Alcock, 1899) and egg case.
9. *Cephaloscyllium silasi* (Talwar, 1974)
10. *Alepisaurus ferox* Lowe, 1833
11. *Bleekeria murtii* (sp. nov)
12. *Caranx lugubris* Poey, 1860
13. *Holapogon maximus* (Boulnger, 1988)
14. *Rhynchobatus australiae* Whitley, 1939
15. *Coelorinchus sheni* Chiou, Shao & Iwamoto, 2004
16. *Pyramodon lindas* Markle & Olney, 1990
17. *Pterocaesio tile* (Cuvier, 1830)
18. *Thryssa vitrirostris* (Gilchrist & Thompson, 1908)
19. *Siganus oramin* (Bloch & Schneider,1801)
20. *Arius venosus* Valenciennes, 1840
21. *Aphareus furca* (Lacepède, 1801)
22. *Etmopterus pusillus* (Lowe, 1839)
23. *Centrophorus atromarginatus* Garman, 1913
24. *Pseudanthias keralensis*(sp. nov)
25. *Pseudanthias cochinensis* (sp. nov)
26. *Sphenanthias whiteheadi* (Talawar, 1973)
27. *Desmodema polystictum* (Ogilby,1898)
28. *Pristipomoides filamentosus* (Valenciennes,1830)
29. *Paracaesio sordida* Abe & Shinohara, 1962
30. *Pinjalo lewisi* Randall, Allen & Anderson, 1987

Mammals

1. *Dugong dugon* (Muller,1776) - Sea cow
2. *Grampus griseus* (G.Cuvier,1812) – Risso's Dolphin

Fish preserved in 1m jars

Stuffed specimen of sea cow, *Dugong dugon* (Muller,1776)

Stuffed specimen of Risso's Dolphin, *Grampus griseus* (G.Cuvier,1812)

Visitors to the Designated National Repository Museum

Total no. of visitors : A total of 7,405 people from 16 States and Union Territories of the country visited the Museum during the period under report.

Students : Students constituted 85% of the total visitors indicating the significant role the Museum plays in education.

Students from : 108 educational institutions from Kerala, 35 from Tamil Nadu, 6 from Maharashtra, 5 from Karnataka, 2 each from Orissa, U. P., M. P., Uttaranchal, Lakshadweep and Andaman & Nicobar Islands and 1each from Andhra Pradesh, Rajasthan, West Bengal,Tripura, Himachal Pradesh and Jammu & Kashmir.

Dignitaries visiting the Designated National Repository

Mr. Gavin Wall from FAO

Students visiting the Museum

Krishi Vigyan Kendra

Technology Transfer

On Farm Testing and Front Line Demonstration Programmes

For the first time in Kerala, maize crop was successfully cultivated through an On Farm Testing conducted by the KVK. The variety PAC 712 brought from Rajasthan Agricultural University gave a potential yield of 40 quintals /ha. With a crop window of 70 days and high photosynthetic efficiency, maize has very good potential in Kerala. The harvest of maize at the demonstration unit of KVK at Thevara, was done on 14-10-2010. Dr. G. Syda Rao, Director, CMFRI, presided over the function and harvested the cobs.

Under On Farm Testing Programmes, nursery rearing of seabass (from hatchery) as a new source of income, adaptability of brush cutter for harvesting paddy, On-farm production of organic manure in coconut garden, testing of new Pokkali paddy Var. VTL-8 and evaluation of new var. of Napier were initiated.

Front Line Demonstration programmes such as Cage culture of sea-bass in open backwater system, scientific management of stem bleeding in coconut using tridemorph and neem cake, eco-friendly management of fruit fly in cucurbits using pheromone trap, cultivation of high-yielding hybrid coconut, 'kerasree', demonstration of hand-operated cassava chipping machine, demonstration of new high yielding cassava var. Shree vijaya were initiated.

Extension Activities

Field Visits

A multi-disciplinary team of KVK visited Kumbhalanghi village as a part of 'Kerapadham' a scheme initiated by the Govt. of India, the tribal village of Vellaramkuthu and conducted training programme on value addition of fruits for the tribals and the areas affected by the leaf roller, a pest of paddy and suggested remedial measures.

Awareness programmes were organized by KVK at Puthuvypu on 16-04-2010, on 27-07-2010 at Renewal Centre, Kaloor, at Ochanthuruthu on 04-09-2010, at KVK Campus for the fishermen of Narakkal Block on 25th June 2010 & 22nd January 2011 and at CMFRI, Cochin on 03-08-2010.

Exhibitions

Exhibitions were organized at Kayamkulam, Alleppey District during 01-04 September, 2010, in Thevara Campus on 14-10-2010, at CMFRI on 29-11-2010, at Narakkal during 09-11 January, 2011 and at Ernakulam Town Hall during 28- 29 March, 2011.

Harvest

Harvesting of new high yielding variety of pokkali paddy var. VTL-8, on 10-10-2010 at Kadamakudy and harvesting of new high yielding variety of Cassava Sreevijaya, on 05-03-2011 at Kothamangalam.

Farmers on exposure visit to KVK

A group of 20 farmers accompanied by 2 officers of Tamil Nadu Agriculture Department visited the KVK on 11-11-2010, 19 farmers and 2 extension personnel of ATMA, Kanyakumari on 18.11.2010, Dairy Extension Officer, Edapally and 40 dairy farmers from Edapally Block on 19.11.2010, 50 farmers accompanied by the Asst. Director, Agriculture of Valakom Block on 01-12-2010, 35 ATMA farmers from Kothamangalam Block on 21.12.2010, 31 dairy farmers accompanied by 2 officers of State Dairy Department, Muvattupuzha Block on 28-01-2011 and 36 farmers accompanied by the Asst. Director, Agriculture of Kanyakumari District, on 18-02-2011 and 19 farmers and two extension personnel of ATMA, Kanyakumari District on 11.03.2011.

Training programmes

On-campus as well as off-campus training courses were organized, for the benefit of farmers, rural youth and extension personnel. Krishi Vigyan Kendra has organized a total of 80 training courses for 2148 villagers including farmers and rural youth in three disciplines *viz.* Agriculture, Home Science and Animal Husbandry.

Vocational Training programmes

For Vocational Higher Secondary School students of Narakkal VHSE, on-job trainingns on 'Aquaculture' and 'Value added products' were conducted during 10-30 November, 2010 and 1-8 December, 2010 respectively.

National training under AICRP

Seven days training programme on 'Scaling up of water productivity in agriculture for livelihood' for 60 farmers at CMFRI, during 1-7 February, 2011.

Other activities

House panel sitting of the Legislative Assembly Committee headed by Shri. K. V. Kunjiraman, MLA at CMFRI, Kochi on 29 November, 2010.

ICAR Director General inaugurates the soil testing lab of KVK

The Director General, ICAR, Dr. S. Ayyappan, inaugurated the "Soil and Water Analysis Laboratory" of Krishi Vigyan Kendra on 26-11-2010 in the Residential Complex of CMFRI at Thevara. To mark the occasion the Hon. DG planted a seedling of nutmeg in the farm.

Demonstration Units Developed at the KVK farm, Thevara

The activities planned and initiated under the demonstration of Sustainable Agriculture for the Urban Landscape programme at CMFRI Residential Complex farm at Thevara is listed below:

- High Value Floriculture
- High Value Olericulture(Vegetables)
- Protected Cultivation
- Roof top garden
- High density planting of banana
- Backyard Poultry (Gramasree)
- Maize Var. PAC712
- Short duration Tapiaco (Sree jaya)
- High Yielding Coconut Variety (Kerasree)
- Hybrid Napier Grass
- Organic waste management through vermi- composting
- Rain water harvesting
- Low cost drip irrigation system

Publications

1. *Panchagavya* authored by Miss. Dipti. N.V., Programme Assistant.
2. *Akittuveekam* authored by Dr. Smita Sivadassan, SMS, Animal Husbandry.
3. *Shasthriya Mannu Parishodhana* authored by Miss. Dipti. N.V., Programme Assistant.
4. *Institute Profile* prepared by Shri. F. Pushparaj Anjelo, SMS, Agricultural Extension and edited by Dr. C. Ramachandran, Programme co- ordinator.
5. *Marachiniyil minisett techniques*, authorised by Shri. Shoji Joy Edison, SMS, Horticulture published in Krishiyanganam, Vol.15.

Radio Programme

2. A programme on 'Banana cultivational aspects' was broadcasted on 13-09-2010 under the kissan Vani programme of AIR, Kochi.
3. A programme on 'Cool season vegetables' was broadcasted on 20-09-2010 under the Kissan Vani programme of the AIR, Kochi.
4. 'Maize cultivation – A farmers view' was broadcasted on 29-09-2010 under the Kissan Vani programme of the AIR, Kochi.

5. 'Fish culture- An interview' was broadcasted on 06-10-2010 under the Kissan Vani programme of the AIR, Kochi.
6. Announcement regarding the sitting of the legislative assembly committee in KVK was broadcasted on 28 &29-11-2010.
7. The coverage of the 'Scaling up of water productivity in agriculture for livelihood ' for the farmers was broadcasted on 15 &16-02-2011 from 6.50 pm -7.00 pm under the Kissan Vani programme of AIR, Kochi.

Trainings Attended

Shri. F. Pushparaj Anjelo, SMS Agricultural Extension attended the 5 days training programme on '*Market Led Extension*' conducted by the MANAGE, Hyderabad from 21st to 25th June 2010.

Shri. F. Pushparaj Anjelo, SMS Agricultural Extension attended the one day training cum awareness programme on 'Protection of plant varieties and Farmers Right Act' conducted by the CTCRI, Trivandrum on 15-12-2010.

Shri. Shoji Joy Edison and Shri. Vijendra Kumar Meena attended the two days training programme on '*Precision Farming*' organised by the Precision farming development centre, Thavannoor on 2nd and 3rd February 2011.

Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR, inaugurating the Soil Testing Laboratory at the CMFRI Residential Quarters, Thevara

Dr. G. Syda Rao, Director CMFRI, inaugurating the maize harvest mela at the Thevara campus of CMFRI

Low cost drip irrigation system developed by KVK for the urban rooftop vegetable gardens

Sitting of the Kerala Legislative Assembly on performance evaluation of KVKs in Kerala

Official Language Implementation

Bilingualisation and targets for correspondence:

During the year, cent percent bilingual issue of Section 3(3) documents (1749 nos.), reply of letters received in Hindi (443) and target of Hindi correspondence (63% against the target of 55%) were ensured. Under bilingualisation of stationery items during the year 46 name plates, 26 rubber stamps, 75 Museum labels, 69 labels of fishes in Hatchery, Identity cards of all staff members of Headquarters and Outstations, 3 charts, 61 Certificates of Hindi Chethana Maas and KVK trainings were prepared. Bilingual standard drafts were prepared and issued to Mumbai Research Centre.

Official Language Implementation Committee meetings: The 82nd, 83rd, 84th and 85th meetings of Official Language Implementation Committee of the Institute were held on 23-06-2010, 30-09-2010, 30-12-2010 and 29-03-2011 respectively.

Review of OL Activities of Regional/Research Centres : The Official Language implementation activities of all Regional /Research Centres were reviewed and suggestions were given for improvement.

Members of the Parliament Committee visiting Mumbai RC on 27.10. 2010

Inspections

a. Parliamentary Committee inspection: The Second sub-committee of Parliamentary Committee on Official Language inspected the implementation activities of Mumbai Research Centre of CMFRI on 27-10-2010.

b. Inspection of Department of OL: Shri M. Vijayakumar, Assistant Director (Impln.), Hindi Implementation Office (S.W.), Dept. of Official Language, M.o. Home Affairs, Cochin inspected the Official Language Implementation activities of CMFRI Headquarters, Cochin on 25-11-2010.

c. Outstation inspections: Director, CMFRI inspected the Official Language implementation activities of Visakhapatnam Regional Centre on 10-02-2011.

d. Assistant Director (OL), CMFRI inspected the Hindi implementation activities of Mandapam Regional Centre of CMFRI on 01-11-2010.

HRD programmes

a. Hindi Workshops: With a view to encourage the staff to work in Hindi without hesitation, three Hindi workshops were conducted at Headquarters, Cochin on 28, 29 and 30 -04-2010, 06,07,08 and 09-09-2010 (Unicode) and 18 and 19-03-2011 (Unicode), One Hindi workshop at Tuticorin Research Centre on 15-07-2010, two workshops at Bombay Research Centre on 18-08-2010 and 25-10-2010 and one Hindi workshop at Mandapam on 02-11-2010.

b. Hindi Teaching Scheme Courses: Two Scientists were deputed to attend Hindi Prabodh course and two stenographers were deputed to attend Hindi stenography course.

Shri K.K.Thripati, Income Tax Ombudsman, Cochin and Chief Guest of Hindi Chethana Mas addressing the staff

Dr.G.Syda Rao, Director, CMFRI receiving Rajarshi Tandon award from Prof. K.V. Thomas, Hon'ble Minister for Food, Agriculture and Consumer Affairs, Govt. of India

Smt. Sheela P.J., Assistant Director (OL) receiving the TOLIC Award from Chief Commissioner of Income Tax, Kochi

c. A word a day: Under *A word a day* programme 286 Hindi words with English equivalents were displayed on the display board.

d. Special incentive scheme: Under the scheme, 8 officers/staff won cash awards. The scheme is in effect at Mangalore/ Calicut Research Centres and Veraval Regional Centre.

e. Attended Town Official Language Implementation Committee meetings at Kochi and outstations. Two meetings of Kochi TOLIC were on 21-04-2010 and 09-11-2010.

Hindi Chethana Mas was observed at CMFRI, Cochin from 1 - 29 September, 2010 with various competitions/ programmes. Shri K. K. Thripati, Income Tax Ombudsman, Cochin was the Chief Guest of valedictory function. Winners of competitions and overall contributors for the year were felicitated during the function. Hindi Day/Week/ Fortnight was observed in all Regional/ Research Centres of CMFRI.

Press and Editorial work performed

a. Quarterly bilingual periodicals released: (i) MFIS - Issue Nos. 201, 202, 203 & 204 (ii) CMFRI Newsletter *Cadalmin* - Issue Nos. 124,125,126 and 127.

b. Special publications released: *Matsyagandha,* 2009

e-governance programmes continued

i) Web display of Tender Notice / Announcemnt

ii) Updation of Hindi website

iii) Use of bilingual software for fishing data collection.

Awards

i) Rajarshi Tandon Award

CMFRI won the Rajarshi Tandon Award (Second position) of ICAR for the excellent implementation of Official Language activities for the year 2009. Dr. G. Syda Rao, Director, CMFRI received the award from Prof. K.V.Thomas, Hon'ble Minister Food, Agriculture and Consumer affairs in the function organized in connection with ICAR Foundation Day on 16th July, 2010.

TOLIC Award

CMFRI bagged Rajbhasha Rolling Trophy (Ist position) of Kochi Town Official Language Implementation Committee for the excellence in Official Language Implementation during the year 2009-2010.

Participation of Scientists in Conferences/Meetings/ Workshops/Symposia / Trainings etc.

Dr. G. Syda Rao, Director

NFDB National level meeting at New Delhi on 6th May, 2010.

Attended the XXII meeting of the ICAR Regional Committee No.VIII at Bangalore during 13-14 May, 2010.

KVK Interaction meeting on 15th May, 2010 at Bangalore.

Indian Aqua Invest Congress and Expo-2010 organized by CIFE, Mumbai during 26- 27 May, 2010.

ASRB-NAIP Launching Workshop at ICAR, New Delhi on 1st July, 2010.

Attended the 217th meeting of the Governing Body of ICAR Society held at New Delhi on 2nd July, 2010.

Directors meeting at ICAR, New Delhi on 14th July, 2010.

Attended the ICAR Foundation Day meeting and received the Rajarshi Tandon Award for the Hindi implementation 2nd prize held at ICAR on 15th July, 2010.

Presided over the Seabass harvest festival and National Workshop on open sea cage farming held at Karwar Research Centre of CMFRI on 17th July, 2010.

Inspection of Parliamentary Committee at Mumbai on 26th October, 2010.

219th Governing Body Meeting of ICAR on 4th January, 2011.

Visited the potential cage culture sites around Machilipatnam on 4th February, 2011.

Visited the cage culture site at Narasapur on 11th February, 2011.

Participated in the Interface of ICAR Directors with the Vice Chancellors of Agricultural Universities on 23rd February, 2011.

Visited Kavaratti and presided over the Workshop on Tuna processing and value addition inaugurated by Dr. N. Vasanthakumar, IAS, Secretary, Fisheries on 4th March, 2011.

RAC Interaction meeting with the Secretary, DARE & DG, ICAR on 17th March, 2011.

Scientists

April, 2010

Participated and delivered talk on Taxonomy of commercially important prawns and Understanding stock-recruitment relationship for fish stock assessment and management during 22 March- 11 April, 2010 at CIFE, Mumbai **- Dr. V. D. Deshmukh**

Centre of Advanced Faculty Training in Fisheries Resource Management from 22nd March – 11th April, 2010 at CIFE, Mumbai- **Dr. S. N. Sethi**

Training programme of CAFT conducted by CIFE Mumbai on 5th April, 2010- **Dr. V. V. Singh**

Marine fishery Census 2010. Funded by DAHD. District supervisor for east and west Godavari Districts, Krishna District and Yanam (UT, Puducheri). Completed the Marine census of families (63761 households) engaged in actual fishing and fishing related activities from the allotted districts during 12th April – 20th May, 2010- **Dr. Prathibha Rohit**

Participated in the stakeholders meeting on commercial production of extruded pellet feed for seabass culture convened by NFDB on 28-04-2010 at Hyderabad- **Dr. P. Vijayagopal**

NFDB meeting on Open Sea Cage Farming at NFDB Hyderabad during 29- 30 April, 2010- **Dr. K. K. Philipose**

May, 2010

Fishery Assessment Working Group (FAWG) meeting of The Bay of Bengal Large Marine Ecosystem (BOBLME) Project on 7h May 2010, Visakhapatnam- **Dr. G. Maheshwarudu, Dr. P. Laxmilatha, Dr. Prathibha Rohit, Shri Ritesh Ranjan, Mrs. Biji Xavier**

ICAR Regional Committee Meeting at KVAFSU, Hebbal, Bangalore during 13-15 May, 2010- **Dr. A. P. Dineshbabu**

Research Advisory Group (RAG) organized by GOMBRT, Ramanathapuram, as a special invitee, on 17.5.2010-**Dr.G.Gopakumar**.

Executive committee meeting of BFFDA, Uttarkannada on 18-05-10- **Dr. K. K. Philipose**

Meeting of the Kerala Coastal Zone Development Corporation meeting for finalizing the draft proposal on the construction of wholesale market in Pangode, Aluva, North Paravur and Pathanamthitta, Kerala state, at Central Institute of Fisheries Technology, Cochin on 14th May, 2010 - **Dr. Shyam S. Salim**

Research Advisory Group (RAG) organized by GOMBRT, Ramanathapuram, as a special invitee, on 17th May, 2010- **Dr. G. Gopakumar**.

Delivered a talk on Open Sea floating cage culture in one day seminars organized by Department of Fisheries at Simar, Sutrapada, Okha and Navibunder, Gujarat on 24, 26, 27 and 28th May 2010- **Dr. Gulshad Mohammed**

IAICE congress and Expo conducted at CIFE Mumbai during 26-28 May, 2010 - **Dr. V. V. Singh**

June, 2010

World Environment Day Celebrations at the Mangalore Refinery and Petrochemicals Ltd, (MRPL) on 5th June, 2010 - **Dr. A.P Dineshbabu, Dr. Pratibha Rohit**

Delivered a talk on Potentiality of open sea cage culture in Gujarat during 'Swarnim Krishi Mahotsav" at Ahmedabad organized by Department of Fisheries, Gujarat on 14th June, 2010- **Dr. Gulshad Mohammed**

July, 2010

Resource person in the Workshop on 'Scientific methods and Writing' organized by Fishery Survey of India on 6th July, 2010- **Dr. (Mrs.) V. Kripa**

Meeting of all the R&D institutions and promotional agencies held on Government Guest House, Thycaud, Trivandrum on 13th July, 2010- **Dr. Rani Mary George**

NAIP sponsored training programme on "Technology Forecasting Methodologies", at IASRI, New Delhi during 13 - 17 July, 2010 - **Dr. R. Geetha**

Delivered a lecture on Fisheries Development of Gujarat, at a meeting organized by State Bank of India at Veraval on 17th July, 2010- **Dr. Gulshad Mohammed**.

National Seminar on Open sea Cage Farming at Karwar, Karnataka during 17-18, July 2010- **Dr. G. Gopakumar, Dr. A. P. Lipton, Dr. D. Narayanakumar, Dr. Imelda Joseph, Dr. A. P. Dineshbabu, Dr. Joe K. Kizhakudan, Dr. Sujitha Thomas, Dr. Geetha Sasikumar, Dr. Geetha Sasikumar, Dr. B. Purushottama, Shri. R. Saravanan**

Faculty for the training programme "Fisheries Data Collection and Fishery Biology" conducted for field staff of the NAIP Project-Value Chain for Oceanic tunas of Lakshadweep during 19- 24 July, 2010- **U. Ganga**

Management Development Programme (MDP) on "Leadership for Innovation in Agriculture" At "MANAGE" Hyderabad, Organised by NAIP during 19-23 July, 2010- **E. M. Abdussamad**

Capacity building workshop on 'WTO and Trade Issues' under the UCTAD-DFID project "Strategies and preparedness for trade and globalization in India at New Delhi during 20-22 July, 2010- **Dr. Shyam. S. Salim**

Participated in the meeting on 'Consensus Building and Environmental Studies on Marine Outfall' under 'Mumbai Sewage Disposal Project, Stage-II (Priority Works)' on 22nd July, 2010- **Dr. V. V. Singh**

"National Biotechnology Meeting" organized by ICAR, NASC, New Delhi on 26th July 2010- **Dr. K. K.Vijayan**

National seminar on 'Ornamental fish culture, and Aquarium keeping' at All Saints College on 28th July, 2010- **Dr. Rani Mary George**

August, 2010

Performance Management training organized by the HRD cell of CMFRI at CMFRI, Kochi on 3rd August 2010 – **Dr. Imelda Joseph**, **Dr. K. S. Sobhana, Dr. Shoji Joseph, Dr. Boby Ignatius, Dr. T.M. Najmudeen, Rekha J. Nair, Dr. Rekha Devi Chakraborty**

Review Meeting-cum-Workshop "Outreach Activity on Fish Genetic Stocks" August 3-4, 2010, NBFGR, Lucknow- **Dr. Srinivasa Raghavan**

Training programme on "SAS- A comprehensive Overview" at GKVK, Bangalore from 9 August to 16 September, 2010- **Dr. Mini K. G.**

NFDB meeting on Open Sea Cage Farming at NFDB Hyderabad from 10- 11August, 2010 –**Dr. K. K.Philipose**

Faculty Development Programme on "Multivariate analysis using PASW statistics" organized by Department of Management Studies, Sree Narayana Gurukulam College of Engineering, Kadayirippu during 12-13 August, 2010- **Dr. N. Aswathy**

4th Meeting of the "Committee for Revalidation of Potential yield of the fishery Resources in the Indian EEZ" as invitee, at CMFRI, Kochi organised by FSI on 13th August 2010 - **E. M. Abdussamad**

Fourth Annual Review Meeting of ICAR Network Project on "Application of Microorganisms in Agriculture and Allied Sectors" (AMAAS) on 17-18 August 2010 in the Conference Hall, NASC Complex, Dev Prakash Shashtri ,Pusa, New Delhi –**K. K.Vijayan, Dr**. **Imelda Joseph**

One day National workshop on by catch: Impact on Marine Fisheries, 18th August, 2010, Mangalore, Karnataka - **Dr. Prathibha Rohit**

Workshop on "By Catch and its impact on Marine Fisheries" at CMFRI Mangalore on 18th August, 2010 - **Dr. (Mrs.) Bindu Sulochanan**

Farmers' Training programme on Seabass farming in Cages organized by the Marine Products Development Authority at Thanneermukkom, Alleppey District, Kerala State. As resource person, delivered a lecture on Pond culture of Seabass on 19th August, 2010- **Dr. K. Asokakumaran Unnithan**

100th Birthday celebration of Dr. S. Jones former Director of CMFRI at Centre for Rehabilitation of Disabled, LMS Compound, Trivandrum on 27th August, 2010- **Dr. Rani Mary George**

Hindi Seminar organized by TOLIC at MRPL, Mangalore on 27th August, 2010-**Dr. Purushottamma**

Joint Hindi workshop under the auspices of Town official language implementation committee, Mangalore conducted by Corporation Bank on 30 Aug 2010- **Dr. (Mrs.) Bindu Sulochanan**

Government of India/ International Labour Organization (ILO) meeting on Fisheries Sector Convention No.188, Cochin, August 31 to September 1, 2010- **Dr. R. Narayanakumar, Dr. C. Ramachandran and Dr. Shyam S. Salim**

September, 2010

Meeting with Prof. K.V. Thomas, Honourable Minister of State for Agriculture and Shri Oommen Chandy, Leader of opposition, Kerala State to discuss issues related Lime Shell dredging in Vembanad Lake at St. Sebastian Higher Secondary School, Aarakunnam, Kottayam District, Kerala on 2nd September, 2010 - **Dr. (Mrs.) V. Kripa and Dr. R. Jeyabaskaran**

5th Meeting of the "Committee for Revalidation of Potential yield of the fishery Resources in the Indian EEZ" as invitee At CMFRI, Kochi. Organised by FSI on 6th September, 2010 - **E. M. Abdussamad**

Task Force meeting on "Aquaculture and Marine Biotechnology" of the Department of Biotechnology (DBT), New Delhi held at the Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar during 7- 8 September, 2010- **Dr. K. S. Sobhana**

Entrepreneur Ready Technologies of CMFRI" in the innovation-4-industry meet organized by Zonal Technology Management Centre, Business Planning & Development Unit, South Zone, CIFT and NFDB held at Visakhapatnam, on 8th September, 2010- **Dr. V. P. Vipinkumar**

Workshop on Hygienic management of fishing harbours and fish landing centers, jointly organized by NFDB, Hyderabad, MPEDA and Department of Fisheries, Kerala at Cochin during 9-10 September, 2010- **Dr. Shyam S. Salim**

NFDB-CMFRI discussions on cage farming held at Cochin on 10-9-2010- **Dr. A. P. Lipton**

Review meeting on Southern Ocean Expedition 2011 at NCAOR, Goa on 16th September, 2010- **Dr. R. Jeyabaskaran**

Delivered a talk on "Biodiversity of Echinoderms with special, reference to sea cucumber resources of India" at the National Conference on Marine Biodiversity" held at Department of Marine Science School of Marine Sciences, Bharathidasan University, Thiruchirappalli, Tamil Nadu on 17th September, 2010- **Dr. P. S. Asha**

First meeting of Inter Institutional Expert Committee (IIEC) for finalizing specifications for equipments/ facilities for the institute under the NICRA project at CRIDA, Hyderabad on 18th September, 2010 - **Dr. (Mrs.) V. Kripa**

Meeting at MPEDA, Cochin to discuss on the European Community Regulation to prevent illegal, Unreported and unregulated fishing and to review the feasibility of the proposed European Community Catch and Re-export Certificate on 18th September, 2010- **Dr. Shyam. S. Salim**

Meeting with Prof. Dr. M. Subramonia Iyer, Associate Director of Research (Soils), KAU-Nodal Officer on ICAR programme on District Contingency Plan Preparation for Agriculture & Allied Sectors of Kerala Agricultural University Background at CMFRI, Kochi on 30th September, 2010- **Dr. (Mrs.) V. Kripa**

October, 2010

Delivered an invited lecture on "Bioinformatics in Fishery Science" at the National Consultative Meet on Bioinformtics in Horticulture' during 9-10 October 2010 at Calicut by Indian Institute of Spices Research- **Dr. K. K. Vijayan**

Second Regional Training Programme on Project Cycle Support Integrated Coastal Management" organized by MoEF in collaboration with IUCN at Chennai during 3- 10 October, 2010 - **Dr. (Mrs.) V. Kripa**

Training programme on 'IT based Decision Support Systems for Digital Content Development' at NAARM, Hyderabad during 5-15 October, 2010- **Dr. A. P. Dineshbabu**

Meeting relating to designing, manufacture and registration of fishing vessels of OAL of 20ft or above at the Secretariat Chamber of Honourable Minister of Fisheries, Govt. of Kerala on 6th October, 2010- **Dr. Rani Mary George**

Participated in the Fishery exhibition 'Krishi Mela' conducted by Agriculture, Horticulture, and Fisheries Department, Karwar in collaboration with NFDB, Hyderabad from 9-11, October 2010 at Karwar Ravindranath Tagore Beach- **Dr. K. K. Philipose**

Talk on "Strengthening economic livelihood opportunities for poor rural women" at Directorate of Women Studies Centre, Cochin University of Science and Technology during the International Day of Rural Women on 15th October, 2010- **Dr. V. P. Vipinkumar**

Workshop on open sea farming organized by MSSRF at Chennai from 21-10-10 to 21-10-10 at MSSRF foundation, Chennai – **K. K. Philipose**

Organized the Interactive programme on 'prospects of cage farming and NFDB assistance' with M/S Jeppiar and associates for the farming work at Muttom at Vizhinjam Research Centre on 23rd October, 2010- **Dr. A. P. Lipton**

Discussion on Ongoing Institutional Programmes of CMFRI in the form of Research projects on Climate change and Marine fisheries to the DDG (Fisheries), ICAR, New Delhi during 24-25, October, 2010- **Dr. V. V. Singh**

International Conference on Climate Change and Environment (ICCCE) at Cochin University of Science & Technology during 25-27 October, 2010- **Dr. (Mrs.) V. Kripa**

Squid taxonomy PIT and Gastropod Operculam Workshop of Molluscan Fisheries Division from 25-30th October, 2010 at CMFRI, Kochi- **Dr. S. N. Sethi**

Delivered the Key note address on 'prospects of cage farming in India' during the inaugural function of the NFDB – sponsored National Training course on Sea Cage farming (as CMFRI HRD programme) held in CMFRI, Vizhinjam, Trivandrum, Kerala on 27-10-2010- **Dr. A. P. Lipton**

Meeting on Abiotic stress management chaired by The Director General and Hon. Agriculture Minister at Baramati during 28-30 October, 2010 – **Dr. V. V. Singh**

Resource persons for National training on "Sea Cage Farming" conducted by CMFRI-NFDB, at Vizhinjam Research Centre of CMFRI, Vizhinjam during October 27 to November 2, 2010- **Dr. Imelda Joseph, Dr. Shoji Joseph, Dr. Boby Ignatius**

November, 2010

Research workshop on coastal regulation zone 2010 notification organized by the Malabar Coastal Institute for Training, Research, and Action 1st November, 2010 - **Dr P. Kaladharan**

Twentieth Swadeshi Science Congress organized by Swadeshi Science Movement (Kerala Chapter of Vigyan Bharathi) & Central Marine Fisheries Research Institute, Cochin during 6- 8 November 2010 - **Dr. (Mrs.) V. Kripa, Dr. K. Asokakumaran Unnithan, Dr. E. M. Abdussamad Dr. K. S. Sobhana, Dr. T. M. Najumudeen, Rekha J. Nair, Dr. Mini K.G., U. Ganga, Dr. P. P. Manojkumar**

CAC meeting of NAIP Project on "Bioprospecting of genes and allele mining for abiotic stress tolerance on 8th November 2010 at NRCPB, New Delhi - **Dr. K. K.Vijayan**

Training programme of "Emotional Intelligence at Workplace and Art of Communication"organized by HRD Cell, CMFRI and Central Board of Workers Education Regional Directorate, Kochi- Ministry of Labour & Employment, Govt of India on 9th November 2010 at CMFRI, Cochin on 11th November, 2010 – **Dr. K. Asokakumaran Unnithan**, **Dr. E. M. Abdussamad, Dr. Somy Kuriakose, Dr. Mini K. G., U. Ganga**

Meeting held at the Regional Director (Environment) at Lalbagh on Environment clearance conditions and monitoring of the state for Coastal Zone Development under the Forest, Ecology and Environment Division of Karnataka state- on 15th November, 2010- **Dr. A. P. Dinesh Babu, Dr. Bindu Sulochanan**

UNCTAD- DFID International Conference on "Progress and Protection through Geographical Indication" held at New Delhi during 16-17 November, 2010 - **Dr. Shyam S. Salim**

Mud Crab harvest Mela organized by the Marine Products Development Authority at Pallipuram in Vypeen Island, Ernakulam Alleppey District, Kerala State on 19th November, 2010- **Dr. K. Asokakumaran Unnithan**

Delivered the inaugural address on ornamental fish culture – their prospects. MATSYAFED programme on 'ornamental fish culture' held in Kovalam, Trivandrum, Kerala on 22nd November, 2010- **Dr. A. P. Lipton**.

Talk on prospects of ornamental fish culture in Karnataka on 24th November, 2010 to the members of the Zilla Panchayat, Uttar Kannada District- **Dr. K. K. Philipose**

Fishery Assessment Working Group (FAWG) meeting of The Bay of Bengal Large Marine Ecosystem (BOBLME) Project at Chennai on 25th November 2010, - **Dr. P. U. Zacharia, Dr. Prathibha Rohit**

Scientific Review Meeting with DG, ICAR at CMFRI, Kochi on 26th November, 2010- **All Scientists at Headquarters**

Fishermen meet organized by Centre for Social Action on 29th November, 2010 – **Dr. V. V. Singh**

December, 2010

Workshop on 'CoML-What next' organized by the NRIC for Indian Ocean Census of Marine Life (IO-CoML) on 1st December 2010, Kochi- **Dr. P. U. Zacharia**

Symposium on "Indian Ocean Marine Living Resources' (Indo MLR) 2010 organized by CMLRE at Kochi during 2-3 December, 2010- **Dr. (Mrs.) V. Kripa, Dr. E. M. Abdussamad , Dr. R. Jeyabaskaran, U. Ganga**

National Seminar on Biodiversity Conservation and Management of Aquatic Resources at Nagercoil organized by Directorate of Research & Extension (Fisheries), Tamilnadu Veterianry and Animal Sciences University, Tuticorin during 9-10 December, 2010 - **Shri. R. Saravanan**

National Seminar on Extension Management Reforms-Initiatives and Impacts organized by the Tamil Nadu Agricultural University, Coimbatore, during 11-12 December, 2010- **Dr. P. S. Swathi Lekshmi**

Group Monitoring Workshop of DST funded project (Characterization of novel antioxidants from Gulf of Mannar; Scheme code: 4090600003) at NIIST Chemical Sciences & Technology Division, National Institute for Interdisciplinary Sciences & Technology (NIIST), Trivandrum on 13th December, 2010 – **Dr. Kajal Chakraborty**

Naional workshop on climate change at Mascot Hotel, Trivandrum organized by Environment Department in collaboration with State Planning Board during 14-16 December, 2010- **Smt. S. Jasmine and Smt. K. N. Saleela**

Akshaya 2010, Technology Week Celebration organized by the Krishi Vigyan Kendra of Central Plantation Crops Research Institute (ICAR), at Kasaragod on 17th December, 2010 - **Dr. K. Asokakumaran Unnithan**

Main & Executive Committee of Mega Fish Festival – 2010 organized by Government of Maharashtra on 17th December, 2010- **Dr. V. V. Singh**

Discussion with NGO partners & TATA Consultancy Services officers regarding launch of m-Krishi mobile service to be applied in Karjat & Neral cluster under the NAIP sub project entitled, 'Strategies to enhance adaptive capacity to climate change in vulnerable regions' on 22nd December, 2010- **Dr. V.V. Singh**

Workshop in connection with Project Proposal writing for Collaborative projects on Tuna Fishery Forecast Systems and fish tagging programmes of INCOIS at Mumbai during 22-23 December, 2010- **Dr. (Mrs.) V. Kripa, Dr. Prathibha Rohit**

Second meeting of Inter Institutional Expert Committee for finalizing specifications of the equipments/ facilities proposed to be procured under the project on 'National Initiative on Climate Resilient Agriculture' at CRIDA, Hyderabad on 27th December, 2010- **Dr. (Mrs.) V. Kripa**

National Biodiversity congress at Trivandrum during 27- 31 December, 2010- **Dr. Rani Mary George**

Meeting of the working group for "Monitoring and review of Implementation of IOTC resolution" Organised by FSI at CMFRI, Kochi on 28th December, 2010- **Dr. E.M. Abdussamad**

January, 2011

Seminar in connection with the State level Women Agricultural Festival, *'Polima'* organized jointly by the various Developmental departments under the Govt. of Kerala at Mathilakom in Thrissur district, Kerala State. Delivered a lecture on Diversification in Aquaculture through Women Self Help Groups on 3rd January, 2010 - **Dr. K. Asokakumaran Unnithan**

Dynamics of Self Help Groups in Mussel Farming' in the NFDB sponsored training programme on Green Mussel Farming, at Calicut Research Centre of Central Marine Fisheries Research Institute on 12th January, 2011- **Dr. V.P. Vipinkumar**

International Symposium Asian-Pacific Aquaculture- 2011 at Kochi during 17-20 January, 2011- **Dr. E. V. Radhakrishnan, Dr. G. Gopakumar, Dr. Sunil Kumar Mohamed, Dr. K.K.Vijayan, Dr. V. Kripa, Dr. R. Narayanakumar, Dr. Imleda Joseph, Dr. Josileen Jose, Dr. K.S. Sobhana, Dr. K. Madhu, Dr. Shoji Joseph, Dr. Boby Ignatius, Dr. Rema Madhu, Dr. Joe K. Kizhakudan, Dr. P. S. Swathi Lekshmi, Rekha J. Nair, C. Kalidas, Dr. S.N. Sethi**

Training programme on SAS: An overview of NAIP project "Strengthening Statistical Computing for NARS", 17-22 January, 2011, UAS, Bangalore- **Dr. Prathibha Rohit, Dr. R. Geetha**

Meeting on Save the Sea through public participation programme organized under the NGO Sagara Chetana, Puthiyappa, Calicut and delivered a talk on save the sea from plastic debris on 19-January 2011- **Shri.K.P.Said Koya**

Sensitization Training on "Bioinformatics Tools and Resources in Fisheries Research" 24 -28 January, 2011 organized by NBFGR, Lucknow **- Dr. Srinivasa Raghavan**

Partners meet on "Application of Bioinformatics in Fisheries Domain" under the NAIP funded project "Establishment of National Agricultural Bioinformatics Grid in ICAR" on 29th Jan 2011 organized by NBFGR, Lucknow- **Dr. Srinivasa Raghavan**

February, 2011

Annual Workshop of the NAIP Sub-project 'Bioprospecting of genes and allele mining for abiotic stress tolerance' on 1 February, 2011 at the Central Institute of Subtropical Horticulture, Lucknow- **Dr. Srinivasa Raghavan**

Training programme on "Capacity Building to enhance the Competitiveness of Indian Fisheries" at the College of Fisheries, Mangalore during 2-4 February, 2011 - **Dr. P. S. Swathi Lekshmi**

Project workshop for implantation of Council monitored Plan Project on National initiative on Climate Resilient Agriculture (NICRA) for XI th plan during 4-5 February, 2011- **Dr. E. Vivekanandan, Dr. Joe K. Kizhakudan, Mrs. Shoba Joe Kizhakudan, Dr. S.N. Sethi, Dr. Somy Kuriakose**, **U. Ganga, Dr.K.K.Philipose Dr. P. S. Swathi Lekshmi and Dr. R. Geetha**

Workshop on Rural Technologies for Sustainable Livelihood at National Institute of Rural Development (NIRD) at Hyderabad and presented on the Entrepreneur- Ready Technologies of Central Marine Fisheries Research Institute on 4th February, 2011- **Dr. V.P. Vipinkumar**

National training on "Molecular diagnostics and fingerprinting of *Salmonella* and pathogenic Vibrios associated with seafood and aquatic environments" organized by CIFT, Kochi during 14-27 February, 2011- **Dr. P. Rameshkumar**

Executive meeting conducted by the TOLIC Kozhikode on 7th February 2011- **Dr. P.Kaladharan**

Meeting with NTNU team from Norway for discussing the open sea cage culture prospects on February 09, 2011 at CMFRI, Kochi – **Dr.K.K.Philipose**

Crustacean Taxonomy workshop at CMFRI, Kochi on 14th February 2011- **Dr.K.K.Philipose**

National Workshop on Research Advances in Fish Vaccines and Prophylactics sponsored by DBT, New Delhi and held at Department of Aquaculture, Fisheries College and Research Institute, TANUVAS, Thoothukudi, Tamilnadu on 15th February, 2011- **Dr. K.S. Sobhana**

Winter school on "Institutional change for inclusive Agricultural growth at IARI, New Delhi during February 15 to March 7, 2011 - **Dr. N. Aswathy**

Meeting of the Expert committee for formulating policy for the leasing of public water bodies, Government of Kerala, Palakkad, 21 February 2011- **Dr. R. Narayanakumar and Dr. C. Ramachandran**

Half-yearly review meeting for AMAAS sub-project from CMFRI in National Bureau of Agriculturally Important Microorganisms MAU on 21st February,2011- **Dr. Kajal Chakraborty**.

Delivered an invited lecture on "Advances in crustacean biology with special reference to aquaculture" in the National Conference organized by University of Madras on 21st February 2011 at Chennai**- Dr. K. K. Vijayan**

Training Programme on "Creative Writing in Agriculture" from 28 February to 4 March, 2011, New Delhi- **Dr. P. S. Swathi Lekshmi**

March 2011

NAIP Training Programme on Data Analysis using SAS , Central Tuber Crops Research Institute, Thirvananthapuram, 3-9 March 2011- **Dr. R. Narayanakumar, Dr. C. Ramachandran, Dr. Shyam S. Salim, C. Kalidas**

NAIP sponsored Workshop on Analytical methods in Fish Stock Assessment with special emphasis on tuna and tuna like resources, Central Marine Fisheries Research Institute, Cochin during 7-11 March, 2011- **Dr. K. S. Sobhana, Dr. Shyam S. Salim**

Resource persons for national training on "Open sea cage culture of marine finfish and shellfish" conducted by CMFRI-NFDB, at Karwar Research Centre of CMFRI, Karwar during March 7-16, 2011- **Dr. V. Kripa, Dr. Imelda Joseph, Dr. P. Vijayagopal, Dr. Sujitha Thomas**

Sensitization Workshop on Results Framework Document (RFD) for Nodal Officers of the Responsibility Centres, New Delhi, during 11-14 March, 2011- **Dr. R. Narayanakumar**

Workshop for the fishermen on 'Climate Change on Indian Marine Fisheries' at the Community hall at Kovalam on 25th March 2011 under the ICAR Network project on "Impact adaptation and vulnerability of Indian Marine Fisheries to climate change - **Dr. A. Margaret Muthu Rathinam, Dr. Joe K. Kizhakudan, Dr. Vidya Jayasankar, Dr. R. Geetha, Mrs. Shoba Joe Kizhakudan.**

Executive committee meeting of BFFDA, Uttarkannada on 26 March, 2011- **Dr. K. K. Philipose**

Cruises

5th Southern Ocean Expedition near Mauritius as a member of the delegation of National Centre for Antarctic and Ocean Research (NCAOR) – during January 20 to March 21, 2011- **Dr. R. Jeyabaskaran**

Chief Scientist onboard FORV *Sagar Sampada* during October 8 – 29, 2010- **U. Ganga**

Lead a team of investigators onboard three converted commercial trawlers for squid jigging and long lining (MV *Titanic*, MV *Ohm* and MV *Cosmos*) in the Lakshadweep Sea from 16-27th October 2010 - **Shri K. P. Said Koya**

Deputation abroad/ International Training

Meeting of the Working Parties on Tropical Tuna of Fishing Capacity at Seychelles on 25th & 26th October 2010 on deputation; presented the prospects of estimating fishing capacity for tunas in India - **Dr. E. Vivekanandan**.

Training on sand lobster seed production at the Australian Institute of Marine Science (AIMS), Townsville, Australia from 31 March to 16 April 2010 under the NAIP project "A value chain on high value shellfishes from mariculture systems- **Dr. Joe K. Kizhakudan**

NAIP sponsored International training on "Microbial molecular taxonomy (Fisheries)" at the Institute of Aquaculture, University of Stirling, Scotland, U.K from 19 August to 18 November 2010- **Dr. S. R. Krupesha Sharma**

Distinguished visitors

World Bank team headed by Sri Paul Singh Sidhu, visited CMFRI from 23-24 May 2010 to review the progress of the NAIP funded projects (component 1-4).

Dr. S. Ayyappan, Secretary, DARE & Director General, ICAR visited CMFRI, Cochin on 26-11-2010.

Dr. B. Meenakumari, Deputy Director General (Fisheries) visited CMFRI Headquarters, Visakhapatnam Regional Centre (7.09.2010), Mumbai (31.08.2010) and Calicut (19.07.2010) Research Centres.

Shri. Tarun Sridhar, IAS, Joint Secretary (Fisheries), Ministry of Agriculture, Government of India and Dr. M. Vijayakumaran, Director General, FSI, Mumbai visited CMFRI, Kochi.

Shri Anand Asnotikar, Hon. Minister for Fisheries, Govt. of Karnataka visited Karwar RC on 17th July 2010.

Shri.P.Krishnaiah IAS, CEO, NFDB visited Karwar RC on 17th July 2010

Shri.Veerappa Gowda, Director, Department of Fisheries, Govt. of Karnataka visited Karwar RC on 17th July 2010.

Shri.V.K.Shetty, MD, KFDC, Govt. of Karnataka visited Karwar RC on 17th July 2010.

Dr. A. E. Eknath, Director, CIFA, Bhubaneswar, Orissa visited Visakhapatnam RC on 25th October, 2010.

Parliamentary Committee inspected the Official Language activities of Mumbai Research Centre of CMFRI on 27th October, 2010.

Dr. V. N. Sharada, Director, Central Soil and Water Conservation Research and Training Institute, Dehradun visited Visakhapatnam RC on 22nd November, 2010.

Dr. N. K. Tyagi, Member, ASRB visited Visakhapatnam RC on 10th December, 2010.

Dr. M.V. Gupta, RAC Chairman, Dr. Madan Mohan, ADG (Marine Fisheries), ICAR and RAC members visited CMFRI, HQ during 28 February - 1st March 2011.

Norwegian Delegates, (Mr. Torbjom Digernes, Rector; Ms. Hilde Skeie, Head of International Section; Prof. Yngvar Olsen, Director of NTNU's; Prof. Harald Ellingsen, Head of Dept. of Marine Technology; Asheesh Agarwal, Senior Market Advisor Royal Norwegian Embassy, New Delhi) visited CMFRI, HQ on 9th February, 2011.

Dr. Kasturi Rangan, Member, Planning Commission of India visited CMFRI Headquarters on 31st January, 2011.

Dr. S. Ayyapan, Director General, ICAR & Secretary, DARE, at CMFRI Headquarters, Cochin

Dr. B. Meenakumari, Deputy Director General (Fisheries) at Mumbai RC of CMFRI

Dr. M. V. Gupta, RAC Chairman and Dr. Madan Mohan, ADG (Marine Fisheries), ICAR during the RAC meeting at CMFRI, Kochi

Central Marine Fisheries Research Institute

Research Locations

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